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U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
MARION B. FOLSOM, *Secretary*

PUBLIC HEALTH SERVICE
LEROY E. BURNEY, *Surgeon General*

If nerve gases, incidentally or accidentally, contaminate public water supplies, the choice of methods for detection and decontamination will be crucial. Satisfactory methods for Sarin and Tabun are assured.

Nerve Gas in Public Water

By JOSEPH EPSTEIN, M.S.

WATER WORKS ENGINEERS, alert to the hazards of radiological, biological, and chemical warfare agents, must be concerned primarily, among the chemicals, with the nerve gases.

Many other chemical agents, because of intrinsically low toxicity if admitted orally, or because of rapid hydrolysis to relatively nontoxic products, are unlikely to appear in hazardous concentrations in a large volume of water. For example, consider hydrogen cyanide and cyanogen chloride, extremely toxic if inhaled. It would take 1 ton of either, uniformly dissolved in a 10-million-gallon reservoir, to reach a concentration of 25 p.p.m. This concentration in water is considered physiologically tolerable for the average man if consumed in normal quantities for a 1-week period (*1*).

More specifically, it would take 1.66 tons of either chemical to reach a 25 p.p.m. concentration in Baltimore's 16-million-gallon capacity Montebello Reservoir; 43,200 tons in Boston's 415-billion-gallon Quabbin Reservoir; 13,500 tons in New York City's 130-billion-gallon Ashokan Reservoir.

In reservoirs of less than 1-million-gallon capacity, the margin of safety owing to dilution is, of course, reduced.

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Even the highly toxic and vesicant lewisite, when viewed in this light, presents little hazard as a water contaminant. Lewisite hydrolyzes almost instantaneously in water to the mildly vesicant oxide. The toxicity of the oxide is apparently due to its trivalent arsenic content, which may be oxidized with ease by chlorine or other oxidizing agents to the less toxic pentavalent state. In fact, trivalent arsenic becomes converted to the pentavalent state upon standing in water.

If water containing lewisite is chlorinated according to standard procedures for bacterial purification and is used for not more than 1 week to avoid possible cumulative effects, as much as 20 p.p.m. of lewisite can be tolerated in drinking water (*1*). Calculation of the quantities of lewisite required to produce concentrations of physiological significance in the bodies of water mentioned previously quickly reveal the improbability that significant contamination of large bodies of water by lewisite will occur as a result of general chemical warfare.

By similar reasoning, the danger of contamination of fairly large bodies of water during general warfare by agents such as phosgene, chloropicrin, chlorine, chloroacetophenone, diphenyl-chlorarsine, and the like is not particularly great.

Although it may appear that the danger of contamination of water supplies by most chemical agents will be small, nevertheless, the possibility of contamination to dangerous levels is a contingency which requires knowledge of the

behavior of chemical agents in water and of methods of water purification or removal of the agents from water.

Quantitative data applicable particularly to the treatment of water contaminated with all but the more recent nerve gases are available (*2*, *3*). For a general history of the nerve gases and information relative to the mechanism of action, effects, and treatment of nerve gas poisoning, the reader is referred to articles by Holmstedt (*4*), Krop and Kunkel (*5*), Grob and Harvey (*6*), Wood (*7*), and Krop and Loomis (*8*).

In discussing the properties and behavior of the nerve gases Tabun and Sarin in dilute aqueous solution, the concentrations will be of the order of $1-2-10^{-4}$ M or about 15–30 p.p.m., unless otherwise noted. The structures and chemical and common names of Tabun and Sarin as well as DFP, an agent similar to Sarin, are shown below.

Toxic Levels of Nerve Gases in Water

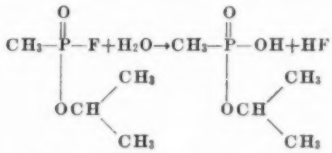
The level of tolerance to Sarin in water has been set at 0.5 p.p.m. with the limitation that the total volume of water taken per day will be no greater than 5 liters and that the period of ingestion will be no more than 3 days (*1*). This sets 2.5 mg. of Sarin as the maximum intake in a 24-hour period, and 7.5 mg. the maximum in a 3-day period. Except for the unlikely case of recontamination, the concentration on the second and third day will probably be somewhat lower than the initial concentration of 0.5 p.p.m., due to the natural and spontaneous hydrolysis of the nerve gas. The products of hydrolysis, from experimentation with rats, can be considered nontoxic.

By comparison of the toxicities to rats, it is estimated that Tabun is about one-fourth as toxic as Sarin via the oral route. A reduction of the "tolerance level" by 10 to 100 times may be advisable when infants or small children are to be the consumers. The quantities of nerve gases, then, which are needed to bring the level of contamination to a tolerance level for reservoirs of medium capacity do not appear to be of a magnitude sufficient to make contamination improbable.

In fact, it must be concluded that it is probable that water will become contaminated to hazardous levels if the nerve gases Sarin and Tabun are employed during warfare.

Hydrolysis of Sarin

Qualitatively, the behavior of Sarin in water is very similar to that of DFP whose hydrolysis in dilute aqueous solution has been thoroughly investigated (*9*). Like DFP, Sarin hydrolyzes to form two acids (equation 1), and the hydrolysis is catalyzed by both acids and bases, although bases are more effective catalysts.



[1]

The rate of hydrolysis is dependent not only upon the pH but also upon the type and quantity of dissolved solids in the water and the temperature of the water.

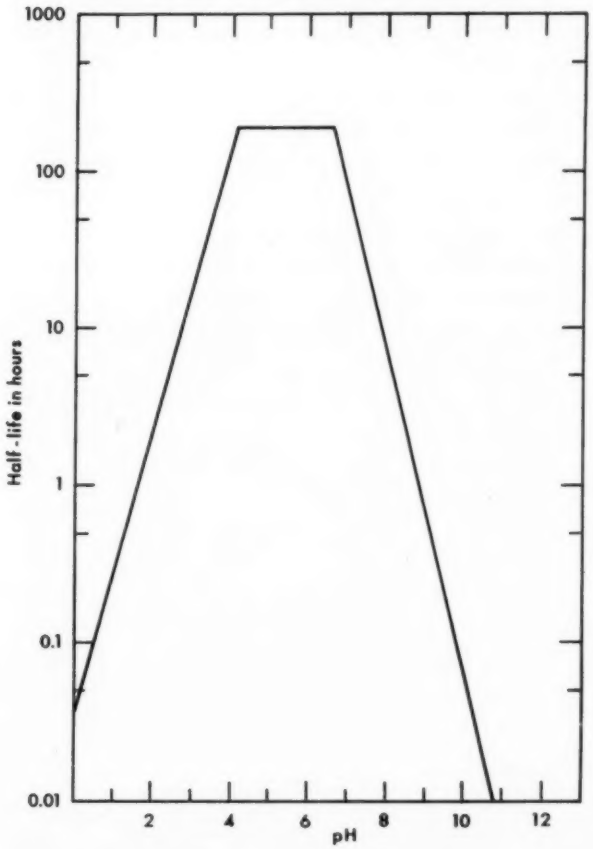
Common Name	*Chemical Name*	*Structure*
Tabun	Dimethylamido ethyl phosphorocyanidate	$(CH_3)_2N-P(=O)(OC_2H_5)-CN$
Sarin	Isopropyl methylphosphonofluoridate	$CH_3-P(=O)(F)-OCH(CH_3)_2$
DFP	Diisopropyl phosphorofluoridate	$(CH_3)_2CHO-P(=O)(F)-OCH(CH_3)_2$

In the absence of large quantities of salts, the half-life ($t\frac{1}{2}$) of Sarin in water at 25° C. (77° F.) at constant pH in the pH range of 6.5 to 13.0 can be estimated from equation 2.

$$t\frac{1}{2} = (5.4 \times 10^8)\ (10^{-pH}) \qquad [2]$$

Thus at pH 7, the half-life of Sarin in water at 77° F. is 54 hours; at pH 8, 5.4 hours; at pH 9, 0.54 hours, and so forth. Between pH 4.0 and 6.5, the hydrolysis rate of Sarin is at a minimum; its half-life in this range is approximately 175 hours. It is evident from equation 2 that above pH 6.5 the rate of hydrolysis increases 10 times per unit increase in pH. Below pH 4.0, the rate increases approximately 10 times per unit decrease in pH. At a given pH, the hydrolysis rate will vary by a factor of approximately 2 for each change of 10° C. The relationship between the half-life of Sarin in dilute aqueous solution at 25° C. and the pH of the water is shown graphically in figure 1.

Figure 1. The relationship between the half-life of Sarin at 25° C. and the pH of water.



The rates of hydrolysis which one might estimate from the use of equation 2 presupposes that the pH will remain constant during the time the Sarin is undergoing hydrolysis. For small concentrations of Sarin, that is, up to 5 p.p.m., in waters containing some buffer capacity, a constant pH will, in all probability, prevail. However, in the absence of significant buffer constituents in the water and at the higher concentrations of Sarin under discussion, the effect of the acidity produced by the hydrolysis may be very important to the stability of Sarin in water. In slightly alkaline water of low buffer capacity, the production of acids caused by a limited hydrolysis of Sarin can lower the pH to the range in which Sarin exhibits maximum stability. Thus, under certain conditions, the hydrolysis of Sarin may produce materials which retard subsequent hydrolysis. In effect, Sarin can stabilize itself.

The rate of hydrolysis of Sarin is accelerated by anions other than hydroxyl ions. The hydrolysis of Sarin is more rapid in the presence of such anions as trivalent phosphate or carbonate ions than might be predicted from the pH of the solution. On the other hand, the hydrolysis rate in the presence of rather large quantities of sulfate, chloride, or nitrate does not materially differ from the rate in water devoid of salts at the same pH. However, the quantities of the catalytic anions, for example, trivalent phosphate, needed to produce appreciable effects upon the hydrolysis rate, will not normally be encountered in water supplies.

Depending upon the pH of the water, some metal ions have strong catalytic effects upon the rate of hydrolysis of Sarin. Cupric, manganous, magnesium and calcium ions, to mention a few, are very effective catalysts, whereas sodium and potassium ions are virtually ineffective. Cupric and manganous salts are more effective in neutral or slightly acidic waters, whereas magnesium and calcium are more effective in alkaline waters.

At pH 6.5 and 25° C., where magnesium salts show practically no effect upon the hydrolysis rate of Sarin, the half-life of Sarin in water containing only 1 p.p.m. cupric ion is 2 hours as compared to a half-life of approximately 175 hours in the absence of the metallic ion. At pH 8.5 and 25° C., on the other hand, where

the cupric ion is ineffective (due presumably to its insolubility) the half-life of Sarin may be decreased from 1.7 hours to 0.5 hours by the addition of 100 p.p.m. magnesium ion. The proportional effectiveness of magnesium ion is greater at alkalinities above pH 8.5, but is less necessary because of the effectiveness of hydroxyl ion alone at a higher pH.

Thus, in waters of high magnesium or calcium ion content, or in waters containing even trace quantities of some heavy metal ions, the hydrolysis rate of Sarin may be much more rapid than that predicted by equation 2. In most natural waters, however, the quantity and type of dissolved solids are such that prediction of the hydrolysis rate may be made from equation 2, provided, of course, that the pH is maintained constant during the hydrolysis.

Hydrolysis of Tabun

The hydrolysis of Tabun, like that of Sarin and DFP, is catalyzed by acids and bases, and bases are more effective than acids (*10*). Unlike Sarin and DFP, whose products of hydrolysis are independent of the catalyst used, Tabun is destroyed by attacks upon different parts of the molecule by acid and base, and the products of hydrolysis are different. In alkaline solution, the phosphorus to cyanide linkage is cleaved, resulting in the formation of a substituted phosphonate and sodium cyanide. In acid solution, the Tabun molecule is cleaved between the phosphorus and nitrogen. Both attacks result in destruction of the toxic properties of Tabun. (See below.)

In alkaline solution, the formation of acid tends to lower the pH of the solution; in slightly acid medium, the hydrolysis products are one acid and one base, and the pH remains constant.

From the data of Larsson (*10*) and Holmstedt (*11*), it appears that the rate of hydrolysis of Tabun at the P—CN bond is for all practical purposes independent of the hydroxyl ion concentration between the pH range of 4.0 to approximately 8.5. The half-life of Tabun in this pH range at 20°–25° C. is 2–4 hours.

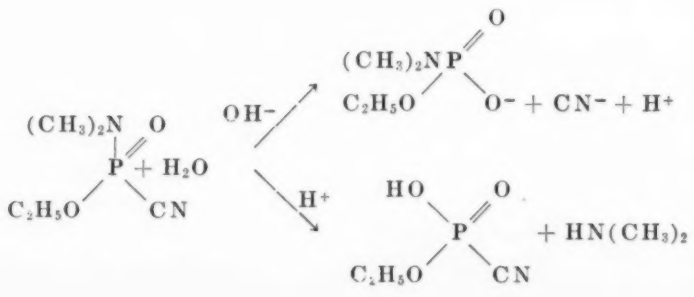
Detection

Although a nerve gas attack would alert water works personnel, Sarin in water in concentrations of at least 35 p.p.m. is not detectable by odor or taste. Water containing concentrations of the hydrolysis products of Sarin as high as 200 p.p.m. was acceptable to rats. However, Tabun, which possesses a fruity odor, is detectable by smell in rather low concentrations. Furthermore, suspicion as to potability of water supply would be aroused by the odor of hydrocyanic acid which is formed by the hydrolysis of Tabun. Unlike Sarin, Tabun, through its released cyanide, will alter the "chlorine demand" of a water.

The uptake of chlorine in the reaction with Tabun will depend upon whether the chlorinating material is hypochlorite or chloramine. The chloramines will react only with cyanide ion which becomes available as a result of the hydrolysis of Tabun. The uptake of chlorine when hypochlorite is one of the reactants is also due to its reaction with cyanide, but apparently hypochlorite ion catalyzes the decomposition of Tabun to form cyanide so that, in effect, the uptake of chlorine is due to the Tabun as well as to the hydrolysis product.

If appreciable quantities of Sarin have hydrolyzed, and the contaminated water if of low buffer capacity, the low pH of the water, resulting from the acidic hydrolysis products,

Hydrolysis of Tabun



may serve to warn that contamination has occurred. An abnormally high fluoride ion concentration in water should arouse the suspicion of the operator as to the potability of the water. However, since only 13 percent of the Sarin molecule after complete decomposition is fluoride ion, probably only when relatively high concentrations are in the water supply would the water be suspected because of fluoride ion concentrations.

The existence of fluoride ion and the low pH can only serve to point out that undecomposed Sarin may be present, not that it is. The same limitations apply to detection methods via the phosphorus moiety of the molecule.

It appears reasonable to conclude that dangerous concentrations of Sarin may remain undetected if only the nonspecific pH and chlorine demand tests and the tests for the fluoride ion and phosphorus are used. However, judicious choice of methods for estimation of fluoride ion concentrations and correlation of these tests with others such as pH and the alteration of the pH of the water observed at various time intervals may be helpful in the detection and estimation of Sarin.

Depending upon the method used for estimation of fluoride ion, one may obtain varying values for fluoride ion in waters containing both unhydrolyzed and hydrolyzed Sarin. If the methods recommended for fluoride in Standard Methods for the Examination of Water and Sewage, Ninth Edition, 1946, are used, then the total fluorine of the hydrolyzed and unhydrolyzed Sarin will be determined, since under the conditions of acidity required for this test, the bound fluorine in Sarin will be converted to ionic fluorine in a few minutes and thus will be determined as ionic fluorine. On the other hand, if fluoride ion is determined in neutral solution, and in the absence of hydrolytic catalysts, then only the fluoride ion present at the time of the test will be determined.

Both Sarin and Tabun in the presence of their hydrolysis products may be detected and estimated rapidly and in very low concentration by their reaction with benzidine or *o*-tolidine and alkaline peroxide solutions (*12*). By means of this reaction, the author and co-workers have been able to estimate quantitatively as little as 0.1 p.p.m. of Sarin in water, and the method can probably be modified to increase the sensitivity.

The test has been adapted for field use and is included in two Chemical Corps water testing kits described in technical bulletins (*13*, *14*).

The response of three small species of fish, the fathead minnow (*Pimephales promelas*), the green sunfish (*Lepomis cyanella*), and the goldfish (*Carassuis auratus*) to Sarin and Tabun are useful to the detection and, in some cases, estimation of small concentrations of nerve gases in water. The approximate LC_{50} (concentration of agent required to kill 50 percent of the test animals) for exposures of 10, 15, and 20 minutes at 70°–75° F. for the three species are shown in table 1.

It is possible to decrease the concentration of the nerve gas necessary to produce an LC_{50} by increasing the exposure time, but with increased exposure times, the effect of the pH of the water becomes very important due to hydrolysis rates of the agents. Thus, for a 24-hour period, the LC_{50} of Sarin for the sunfish is 2 p.p.b. (.002 p.p.m.) if the water is kept at pH 6.5 (minimum hydrolysis), but 9.5 p.p.b. at pH 8.0. Similar data have been obtained with the other species for Sarin and Tabun.

The LC_{50} values are increased if the temperature of the water is lowered. For a change of approximately 25° F., the LC_{50} values for a 10-minute exposure should be multiplied by 6 to 8 for the three species.

Table 1. Approximate LC_{50} of Sarin and Tabun (p.p.m.) for fish at 70°–75° F., by various exposure times

Fish species	Tabun			Sarin		
	Minutes of exposure			Minutes of exposure		
	10	15	20	10	15	20
Green sunfish	1. 5	1. 0	0. 70	0. 35	0. 23	0. 27
Fathead minnow	1. 5	. 9	. 60	. 63	. 40	. 3
Goldfish	2. 4	1. 7	1. 3	. 93	. 6	. 5

Decontamination

On the premise that decontamination procedures should reduce the level of Sarin and

Tabun concentration to 0.1 p.p.m., field tests have shown that coagulation with ammonium alum, followed by filtration through diatomite or sand filters is not an effective decontaminating procedure. A procedure involving the use of ferric chloride as coagulant and powdered limestone as coagulant aid, followed by filtration through diatomite filters is also ineffective. These materials are used in the Corps of Engineers Mobile Water Purification Unit (*15*).

Approximately 62 pounds of carbon would have to be added to each 1,000 gallons of water to reduce the concentration of 30 p.p.m. to 0.1 p.p.m. A smaller total dose of carbon can accomplish the same objective if a multiple treatment procedure is applied. However, the time involved and the multiplicity of operations make such a procedure objectionable.

Sarin in water is rapidly hydrolyzed by the catalytic action of strongly basic ion exchange resins, such as Amberlite IRA–400 and Nalcite SAR and strongly acidic cationic resins such as Dowex 50 and Amberlite IR–112. The anionic resins are more effective, and function not only as catalysts, but also remove the hydrolytic products. In doing so, however, the resins lose their available hydroxyl ion and ultimately their ability to catalyze the hydrolysis.

Furthermore, in water of appreciable dissolved solid content, the anions of the salts replace the hydroxyl groups in the resin (and cations, the hydrogen ions of the cationic resins) resulting in a decreased efficiency of the resin, since the efficiency is related to the number of available hydroxyl or hydrogen ions in the resin. The use of resins for large scale water decontamination is not economically feasible.

At least two feasible methods for the destruction of Tabun and Sarin in water supplies are available. Both methods are based upon an acceleration of the normal hydrolysis rate. The methods involve chlorination or alkalinization.

Chlorine will not react with Sarin, but hypochlorite ion is a very effective catalyst for the hydrolysis of both Sarin and Tabun. Compounds containing combined chlorine, such as chloramine T, on the other hand, exert practically no catalytic action. Table 2 shows the half-life of Sarin in water at approximately

Table 2. Half-life of Sarin (2×10^{-4}M) in water in the presence of free chlorine

Temperature	pH	p.p.m. Cl_2	Half-life in minutes
77° F.	6	200	11
	7	25	13
	8	9	12
	9	4	15
36°–37° F.	6	200	38
	7	100	12
	8	100	3
	9	50	4

77° F. and 35° F. at various pH's and in the presence of free chlorine, added as high test hypochlorite (HTH).

The importance of pH in this reaction is seen from the figures shown in table 2 on experiments at 77° F. Only one-eighth of the chlorine concentration was required at pH 7.0 as was required at pH 6.0 to give approximately the same rate of destruction. Approximately one-third the concentration of chlorine was required at pH 8.0 to produce the same effect at pH 7.0, and so forth. It can also be seen by comparing the half-lives of Sarin in the presence of equal concentration of chlorine and at the same pH but at two different temperatures, for example, pH 6, that the rate of destruction is approximately doubled for each rise of 10° C.

Where time of treatment can be extended to several hours, much lower concentrations can be used to produce effective decontamination. For example, by maintaining the water at pH 8.0, addition of 5 p.p.m. chlorine will reduce the concentration of Sarin from 30 to 0.1 p.p.m. in approximately 3 hours. Figure 2 shows half-life of Sarin at 25° C. at pH ranges between 6 and 9 in the presence of different concentrations of free chlorine.

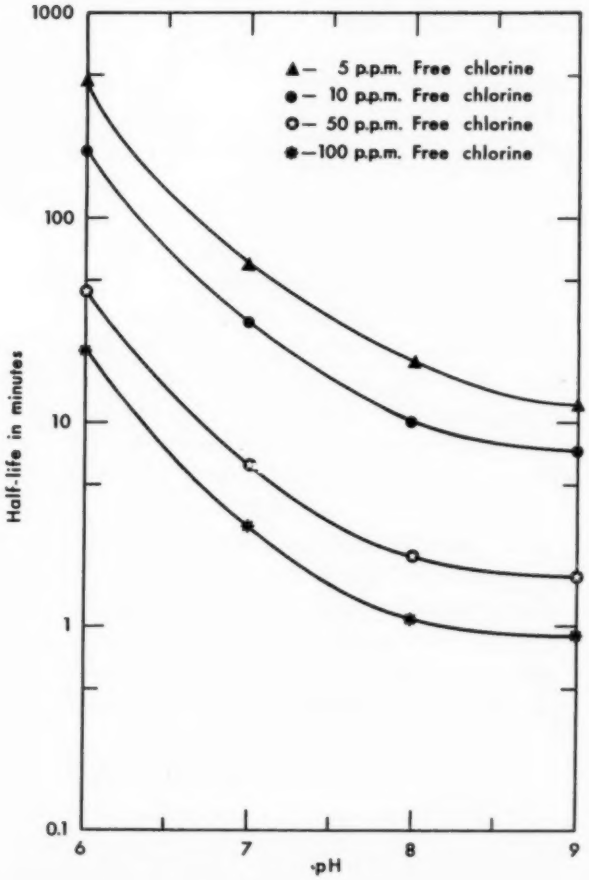
A dosage of chlorine to be added to a water supply may be calculated from the values given in figure 2, a knowledge of the concentration of Sarin in the water, the temperature and pH of the water. The action of hypochlorite may be completely inhibited, however, if amines or ammonium salts are present in the water because of the very rapid reaction of hypochlorite with the nitrogen compounds to form chloramines (*16*) which are catalytically inactive.

Chlorine as hypochlorite will destroy Tabun, and the cyanide produced upon hydrolysis of Tabun will consume the chlorine.

Satisfactory procedures for decontamination of Sarin have been developed, utilizing the catalytic properties of hypochlorite. In field trials, HTH was used as the source of hypochlorite and, because rapid decontamination was desired, 100 p.p.m. chlorine was used. Following decomposition, the hypochlorite concentration was reduced to less than 1 p.p.m. by treatment with activated carbon.

Another satisfactory procedure for decontamination proved by field trials is to raise the pH of water to approximately 10.0 with soda ash, slaked lime or magnesium hydroxide, allow the Sarin or Tabun to hydrolyze, and when tests indicate that the concentration of the nerve gas is 0.1 p.p.m. or less, use a coagulant such as ammonium alum or ferric chloride, filter and chlorinate. The rate of hydrolysis is followed by the test methods described (*14*) and the quantity of alkaline material to be added is regulated by the rate of hydrolysis. The alum or ferric chloride function not only as coagulants but also to reduce the pH of the water to normal acidities. Water treated by either procedure is potable and palatable.

Figure 2. The relationship between the half-life of Sarin at 25° C. and the pH of water for different concentrations of free chlorine.



Conclusion

From the preceding discussion, it appears reasonable to conclude that, in the event of general chemical warfare, the nerve gases Tabun and Sarin must be considered potential water contaminants because of the very small quantities of these agents required to produce toxic symptoms from ingestion. The hazard due to Tabun, however, is lessened somewhat because of its ease of detection in water by taste, odor, and chlorine demand test. Sarin presents a more difficult problem inasmuch as specific detection methods are necessary. Once detected, both Sarin and Tabun can be rapidly destroyed by simple decontamination procedures.

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The Mayo Memorial

Forming the heart of what is virtually a complete medical center on the University of Minnesota campus is the recently completed Mayo Memorial. The university's School of Public Health occupies 2½ floors of the new building's 14-story tower section.

The Mayo Memorial, which was dedicated on October 21, 1954, is the fulfillment of an idea begun more than a decade ago. In 1939, shortly after Doctors Charles H. and William J. Mayo had died, the Governor of Minnesota appointed a Mayo Memorial Commission to propose an appropriate monument. After considering many projects, the commission agreed that a center for teaching and research as a building of the University of Minnesota Medical Center would be the most fitting memorial. During their lifetime, the Mayo brothers had devoted much time, interest, and aid to the work of this institution.

A Committee of Founders started the project on its way. Funds were raised by legislative appropriation, public subscription, and grants from public and private agencies. Construction was started in 1951 and completed in the early autumn of 1954.

The new building brings together the facilities of the School of Public Health formerly scattered in several university buildings. On the 11th floor are laboratories, offices, and classrooms for work in environmental sanitation and epidemiology. The 12th floor houses facilities for biostatistics, health education, and the course in hospital administration. The public health nursing unit, offices for the nonprofessional health and hygiene courses, and other offices are located on the 13th floor, which the school shares with the medical school administration. Conference and reading rooms are provided on each of the three floors used by the School of Public Health.

In addition to the tower section, the Mayo Memorial has three 6-story wings that connect with existing hospital and medical school buildings. The building has facilities for education, research, and service in connection with various departments of the medical school.

Present Status of Controlled Fluoridation in the United States

CONTROLLED water fluoridation for the prevention of dental caries started in 1945 with study projects in three communities—Newburgh, N. Y., Grand Rapids, Mich., and Southbury Training School in Connecticut. The study projects were a natural outgrowth of earlier epidemiological research in cities where fluoride has been present naturally in the water supply, and which demonstrated the inverse relationship between fluoride-bearing water and dental caries experience.

Reports of lowered caries incidence in the study communities were published in 1950 (*1–3*). As a result of these and other studies, the fluoridation of water supplies was endorsed by national health organizations and the practice adopted by many communities.

Summarized is the present status of controlled water fluoridation in the United States. The summary data include the number of communities, water supply systems, and population served by fluoridated water; the date the procedure was instituted; ownership of the water plant, and authorization for fluoridation. These data are presented primarily as reference material.

From 1945, when controlled fluoridation was introduced, through May 2, 1956, 1,352 communities served by 727 water supply systems instituted fluoridation (table 1). Sixty-six communities (5 percent of the total) served by 54 water supply systems discontinued fluoridation. Of these, 7 communities, each one its own water supplier, reinstituted the procedure.

By May 2, 1956, a net total of 1,293 communities with 26 million people were served by 680 water supply systems to which fluoride had been added.

The annual increment in the number of communities and water supply systems in which fluoridation was initiated, discontinued, and reinstituted and the population they serve is shown in table 2. The greatest increase in the initiation of fluoridation occurred during 1952. Subsequently, annual increments in number of communities, water supply systems, and population have been at a lower level.

Table 3 shows the number and percentage of communities in each of 11 population groups using fluoridated water at the end of 1955.

Of the 1,255 communities using controlled fluoridation at the end of 1955, nearly 30 percent are under 1,000 in population, or of size not specified. Most of the latter are quite small since no population figures were available from Bureau of the Census sources. A little more than 30 percent of communities using fluoridation range in size from 1,000 to 5,000 population. Another 30 percent are between 5,000 and 50,000 population. The remaining 6 percent are over 50,000 in size.

When these figures are compared with the total number of communities of given size, nearly 45 percent of the communities of 500,000 population or over are fluoridating their water supplies, and from 20 to 30 percent of the com-

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Prepared by the Division of Dental Public Health, Bureau of State Services, Public Health Service, Department of Health, Education, and Welfare.

Table 1. Annual cumulative findings on the institution, discontinuance, and reinstitution of controlled fluoridation showing number of communities, water supply systems, and population served, January 1945–May 2, 1956

Year	Fluoridation status at end of each year			Fluoridation instituted whether or not discontinued		
	Number of communities	Number of water supply systems	Population	Number of communities	Number of water supply systems	Population
1945	6	3	231, 920	6	3	231, 920
1946	12	8	328, 467	12	8	328, 467
1947	16	11	454, 748	16	11	454, 748
1948	24	13	577, 683	24	13	577, 683
1949	45	29	985, 357	45	29	985, 357
1950	94	62	1, 496, 887	95	63	1, 513, 437
1951	325	171	4, 851, 420	327	173	4, 880, 870
1952	711	354	13, 280, 096	717	360	13, 423, 736
1953	944	483	16, 708, 847	955	494	16, 804, 039
1954	1, 119	570	20, 918, 518	1, 150	599	22, 060, 118
1955	1, 255	663	24, 400, 842	1, 310	706	25, 871, 813
1956 [1]	1, 293	680	25, 911, 490	1, 352	727	27, 453, 633

Year	Fluoridation discontinued whether or not reinstituted			Fluoridation reinstituted after discontinuance		
	Number of communities	Number of water supply systems	Population	Number of communities	Number of water supply systems	Population
1945						
1946						
1947						
1948						
1949						
1950	1	1	16, 550			
1951	2	2	29, 450			
1952	6	6	143, 640			
1953	13	13	204, 945	2	2	109, 753
1954	35	33	1, 267, 811	4	4	126, 211
1955	61	49	1, 601, 651	6	6	130, 680
1956 [1]	66	54	1, 680, 455	7	7	138, 312

[1] Through May 2, 1956.

munities of 10,000 to 50,000 population. For communities of less than 10,000 population, the percentage of fluoridation ranges from 4 to 14 percent. The proportion of communities that have instituted controlled fluoridation increases almost directly with grouped community size.

Public or private ownership of water supply facilities and authorization by which fluoridation was instituted, by grouped size of community, are shown in table 4.

It is interesting to note that of the 1,255 places with fluoridation as of December 31, 1955, more than a thousand owned their own water plants, and in 160 places the plants were under private ownership. Of the privately owned plants, 68 percent were in places of under 10,000 population. Distributed on the basis of size of towns, however, 17 percent of the places under 10,000 population and 9 percent of the towns over 10,000 had privately operated water plants.

Table 4 also shows that in almost all communities the problem of whether or not to fluoridate is decided by the governing body. In only 6 percent of the communities was the question of fluoridation decided by referendums.

This census shows that in May 1956, after more than 10 years of water fluoridation, approximately 26 million people in about 1,300 communities, or roughly 1 out of every 4 people

using central water supplies, were drinking water with an adjusted fluoride content.

During the last few years, the number of people drinking fluoridated water has increased by about 4 million persons a year.

There is every reason to believe that this rate of increase will not decline and may very well become greater. However, as of May 1956 only 6 percent of the towns and villages of under 10,000 population had fluoridation, even though

Table 2. Annual incremental findings on the institution, discontinuance, and reinstitution of controlled fluoridation showing number of communities, water supply systems, and population served, January 1945–May 2, 1956

Year	Fluoridation instituted whether or not discontinued			Fluoridation discontinued whether or not reinstituted			Fluoridation reinstituted after discontinuance		
	Number of communities	Number of water supply systems	Population	Number of communities	Number of water supply systems	Population	Number of communities	Number of water supply systems	Population
Total	1, 352	727	27, 453, 633	66	54	1, 680, 455	7	7	138, 312
1945	6	3	231, 920						
1946	6	5	96, 547						
1947	4	3	126, 281						
1948	8	2	122, 935						
1949	21	16	407, 674						
1950	50	34	528, 080	1	1	16, 550			
1951	232	110	3, 367, 433	1	1	12, 900			
1952	390	187	8, 542, 866	4	4	114, 190			
1953	238	134	3, 380, 303	7	7	61, 305	2	2	109, 753
1954	195	105	5, 256, 079	22	20	1, 062, 866	2	2	16, 458
1955	160	107	3, 811, 695	26	16	333, 840	2	2	4, 469
1956 [1]	42	21	1, 581, 820	5	5	78, 804	1	1	7, 632

[1] Through May 2, 1956.

Table 3. Total communities in the United States, by size group, compared with the proportion of each using controlled fluoridation, December 31, 1955

Population size of community	Number of communities in urban and rural area [1]	Communities using controlled fluoridation	
		Number	Percent of all communities of same size
Total	18, 548	1, 255	6. 8
1,000,000 and over	5	1	20. 0
500,000–999,999	13	7	53. 8
250,000–499,999	23	6	26. 1
100,000–249,999	65	19	29. 2
50,000–99,999	126	37	29. 4
25,000–49,999	252	70	27. 8
10,000–24,999	778	162	20. 8
5,000–9,999	1, 176	163	13. 9
2,500–4,999	1, 846	200	10. 8
1,000–2,499	4, 296	226	5. 3
Under 1,000 and not specified	9, 968	364	3. 7

[1] SOURCE: Number of places in urban and rural territory, by size of place: 1950. Statistical Abstract of the United States, United States Bureau of the Census, 1955, table 15, p. 23.

Table 4. Ownership and authorization for fluoridation in places fluoridating as of December 31, 1955, by size of community

Population size of community	Number of communities	Ownership			Authorization				
		Public	Private	Not specified	Governing body alone	Referendum	Utilities commission	Other	Not specified
Total	1,255	1,093	160	2	1,061	62	56	53	23
1,000,000 and over	1	1			1				
500,000–999,999	7	7			6	1			
250,000–499,999	6	5	1		6				
100,000–249,999	19	18	1		16			2	1
50,000–99,999	37	31	6		33	1		2	1
25,000–49,999	70	63	6	1	60	2	2	3	3
10,000–24,999	162	151	11		138	12	5	5	2
5,000–9,999	163	141	22		146	4	1	8	4
2,500–4,999	200	177	23		168	5	6	14	7
1,000–2,499	226	197	28	1	197	3	10	12	4
Under 1,000	154	118	36		139	7	4	3	1
Not specified [1]	210	184	26		151	27	28	4	

[1] Presumably under 1,000. The names of the towns are known, but their populations are not reported.

some 45 percent of the cities of more than 500,000 population were using fluoridated water. In numerical terms, this means 10 cities of over 500,000 persons do not have fluoridation and some 16,000 communities of under 10,000 population are not using fluoridated water.

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Public Health Engineering Abstracts, published by the Public Health Service, is now on sale at the Government Printing Office. Subscriptions can be obtained by writing to the Superintendent of Documents, Washington 25, D. C. Prices are $2 per year, domestic; $2.50 per year, foreign; 20¢ per individual copy.

This publication reviews monthly more than 600 domestic and foreign technical publications. The annual index includes a cross-reference by subject, author, and publication.

Analysis of a Hospital Consultation Program

By HELEN M. WALLACE, M.D., MARGARET A. LOSTY, R.N., ROBERT S. SIFFERT, M.D., JEROME S. TOBIS, M.D., and MIRIAM LENDING, M.D.

APPRAISAL of the effectiveness of individual programs is one of the basic needs in public health administration. All too frequently programs are initiated without an accompanying plan for evaluation. Or they are perpetuated without critical review and analysis to determine whether the originally planned objectives are being achieved. While it is not always easy to stimulate the development of new programs, sometimes it may be equally difficult to discontinue or modify old programs that prove to be partially or totally ineffective; frequently the underlying reason is the lack of substantiating facts of an evaluative nature.

Evaluation of public health programs should provide answers to two basic questions: (*a*) Is the program making a significant contribution toward improving the health of the public served? (*b*) Is the program making good use of the tax funds expended for the purpose? It is logical that if the answers to both questions are affirmative an existing program should be continued. If the answers are negative, the program should be reviewed carefully and either modified significantly or discontinued.

Since 1952 the bureau for handicapped children of the New York City Department of Health has provided consultation to hospitals participating in the health department's program for orthopedically handicapped children. To assess the value of this hospital consultation program, we have examined the results thus far and are reporting the findings.

Dr. Wallace is professor of maternal and child health, University of Minnesota School of Public Health. At the time of this study she was director of the bureau for handicapped children, New York City Department of Health. With the bureau are Miss Losty as hospital nursing consultant, Dr. Siffert, senior orthopedic consultant, Dr. Tobis, consultant in physical medicine and rehabilitation, and Dr. Lending, pediatric consultant. Herbert Rich, senior statistician of the bureau of records and statistics, assisted in the statistical presentation.

Background Information

The New York City Department of Health now spends approximately $2 million annually for the hospital and convalescent care and rehabilitation of children with many other types of handicaps besides orthopedic—congenital cardiac, orthodontic, plastic surgical, hearing, cleft palate, epilepsy, drug addiction, visual, and miscellaneous types. Within this broad diagnostic list, the orthopedic category remains one of the larger groups because it represents the original program for handicapped children in New York City. Some of the other categorical programs are only a few years old. The bureau staff has developed hospital consultation for most of these categorical groups.

Hospital consultation has been carried on for many years in the fields of epidemiology and maternal and newborn care and for a shorter time in the field of general hospital care (because of the Hill-Burton Act). But to our knowledge the hospital consultation program

for handicapped children in New York City is the first of its kind in the field of chronic disease in children.

The details of this program have been presented in another report (*1*), but briefly the hospital consultation program functions in the following manner:

1. An advisory committee recommends a set of standards.
2. A team of specialists surveys the institutional services in the particular fields concerned.
3. The team then transmits a letter of recommendations to the key personnel of the institution.
4. At a postsurvey conference, the specialists discuss the recommendations with the key members of the institutional staff.
5. The survey team conducts followup activities, depending on the needs and requests of the individual institutions.

In the bureau's consultation program in the orthopedic field, the services of 25 children's hospitals have been surveyed by a team composed of an orthopedic surgeon, a pediatrician, a physiatrist, a hospital nursing consultant, and a medical social worker. Letters of recommendation have been sent to the staffs of 24 hospitals, and postsurvey conferences have been held with the staffs of 22 hospitals. Of the 25 hospitals, 15 are large general hospitals; 5 are specialty hospitals devoted predominantly or exclusively to the care of the orthopedically handicapped; 4 are for chronic diseases and 1 for communicable diseases.

We have taken as the endpoint in this analysis the information collected at the postsurvey conferences.

Survey Recommendations and Results

The survey data have been subdivided into four headings for presentation: (*a*) policies and procedures; (*b*) personnel; (*c*) accreditation; (*d*) physical plant and equipment. These four headings represent the great majority of all the recommendations made. To arrive at a simple summary of the survey data, a function "hospital-items" has been used. It is the product of the number of hospitals times the number of items evaluated, recommended, or adopted in any particular subgroup. Thus, in the policies and procedures group, 25 hospitals were surveyed and 15 items evaluated, that is, 375 hospital-items. In all, 189 hospital-items were recommended under the policies and procedures heading (50 percent of the 375 hospital-items evaluated in this category); 95 pertained to personnel (38 percent); 13 to accreditation (17 percent); and 12 to physical plant and equipment (24 percent).

Policies and Procedures

In the policies and procedures area a total of 91 recommendations pertained to inpatient service only, 63 recommendations to outpatient service only, and 35 recommendations to both services. Thirty-five percent of the recommendations were adopted by the hospitals (table 1).

For inpatient service, the recommendations of individual items varied in frequency from advising the team approach to patient care in 24 hospitals to advising improvement of social service and occupational therapy notes in 5 hospitals. Implementation of recommendations by the hospitals varied from 60 percent for improvement in social service records to 29 percent for developing a team approach to patient care. Changes were made most frequently as a result of the recommendations in the most specific, simplest, and superficial areas, such as recording of patient information. The least frequent implementation occurred in the conceptual area of patient care—the team approach, which signifies that the optimum care of the handicapped child requires the participation of many professional disciplines working together as a team.

Only about one-third of the hospitals in which the recommendations concerned the inpatient service improved their pediatric supervision of children and improved their pediatric notes. Also only one-third of the hospitals liberalized visiting hours for the parents of the children. Although this type of recommendation does not deal specifically with the orthopedic care of the child, its importance should not be minimized since the consideration of the "child" is as important as the consideration of the "patient." Too often the child leaves the hospital with a healed operative scar but with an unhealed scar resulting

Table 1. Recommendations regarding policies and procedures, 25 hospitals

Recommendation	Hospitals in which recommended		Hospitals applying recommendation	
	Number	Percent	Number	Percent
Inpatient service only				
Use team approach	24	96	7	29
Provide pediatric supervision	14	56	5	36
Liberalize visiting hours	14	56	5	36
Improve pediatric notes	10	40	3	30
Refer for vocational counseling	10	40	4	40
Improve physical therapy notes	9	36	3	33
Incorporate social service notes in patient's record	5	20	3	60
Improve occupational therapy notes	5	20	2	40
Total hospital-items (200)	91	45	32	35
Outpatient service only				
Set up appointment system in orthopedic outpatient department	17	68	0	0
Establish children's orthopedic clinic	15	60	4	27
Set up conference in orthopedic outpatient department	14	56	4	29
Arrange for followup of broken appointments	10	40	3	30
Change cast at time of clinic visit	7	28	5	71
Total hospital-items (125)	63	50	16	25
Inpatient and outpatient services				
Set up unit system of records	18	72	7	39
Referral to visiting nurse association	17	68	11	65
Total hospital-items (50)	35	70	18	51
Grand total hospital-items (375)	189	50	66	35

from failure to consider all his needs—social, psychological, and followup, as well as pediatric and therapeutic. Improvements in outpatient service only were recommended 63 times and carried out 16 times (25 percent). The most frequent recommendation, that of instituting an appointment system, was not applied in any hospital. Implementation was obtained in approximately one-third of the recommendations for (*a*) a separate children's orthopedic clinic; (*b*) an effective followup of children failing to keep clinic appointments; and (*c*) for developing clinic staff conferences. In seven hospitals it was recommended that, for the convenience of the child and his mother, cast changes, where indicated, be performed at the time of the clinic visit instead of requiring another clinic visit on another day; almost three-quarters of the hospitals adopted this procedure.

Two major recommendations applied to both the inpatient and outpatient services. One consisted of the referral of patients to the voluntary public health nursing agencies in the community for home followup, public health nursing supervision, and physical therapy. This recommendation was adopted in two-thirds of the instances. The other consisted of setting up a unit system of records in the hospital to provide continuity of recorded information in the hospital setting. This recommendation was carried out by 39 percent of the hospitals.

Personnel

A total of 95 recommendations pertained to personnel caring for orthopedically handicapped children and were carried out in 37 instances, or 39 percent (table 2).

The frequency of personnel recommendations

varied from the assignment of a pediatrician to the children's orthopedic clinic in 17 hospitals to the appointment of a qualified director of the anesthesia services in 4.

Where recommended, about 60 percent of the hospitals employed physical therapy staff and improved services for psychological testing of the children. About 50 percent improved the medical supervision of the hospital's department of physical medicine and rehabilitation and appointed a qualified director of the anesthesia service. About 40 percent appointed a qualified nurse in charge of the children's orthopedic service, provided 24-hour coverage of the service by a registered professional nurse, arranged for additional work experience in orthopedic nursing for the nursing staff, and employed an additional social worker for the children's orthopedic service. However, only one-fifth of the hospitals were able to develop a department of physical medicine and rehabilitation within the hospital or to assign a pediatrician to the children's orthopedic clinic.

Accreditation

Thirteen hospitals were counseled to seek accreditation by the American Board of Orthopedic Surgery or the American Board of Pediatrics or to seek a modified pediatric residency in affiliation with a hospital approved for this purpose within the community. None of these hospitals were able to fulfill any of these recommendations, although 2 of the 6 hospitals tried to obtain approval for an orthopedic residency training program, and 1 hospital tried to obtain a pediatric resident on an affiliated basis (table 3).

No recommendations were made for residency approval in the specialty of physical medicine and rehabilitation because practically all of the hospitals with departments of physical medicine and rehabilitation are also approved for residency training in the specialty.

Physical Plant and Equipment

In 12 instances, improvements were recommended in the physical setup, divided equally between the inpatient and outpatient services (table 4). Three of the hospitals carried out the recommendation for the inpatient service and only one hospital for the outpatient service. In addition, during the survey period, two hospitals (one a large general hospital and the other a large specialty hospital) constructed entirely new buildings, and a third hospital (a large specialty hospital) undertook an extensive reconstruction program. In these three instances, the bureau staff participated in a review of proposed blueprints but could not be credited as being the instigating force for the change.

Illustrating the types of recommendations made for the inpatient service are: installation of running water in a large children's ward;

Table 2. Recommendations for personnel, 25 hospitals

Recommendation	Hospitals in which recommended		Hospitals applying recommendation	
	Number	Percent	Number	Percent
Assign pediatrician to children's orthopedic outpatient department	17	68	3	18
Provide 24-hour nursing coverage by registered nurses	16	64	7	44
Develop department of physical medicine and rehabilitation	10	40	2	20
Employ physical therapy staff	10	40	6	60
Appoint qualified charge nurse	9	36	4	44
Provide training in orthopedic nursing	8	32	3	38
Employ social worker	8	32	3	38
Improve psychological testing service	7	28	4	57
Improve medical supervision in physical medicine and rehabilitation	6	24	3	50
Appoint qualified director of anesthesia service	4	16	2	50
Total hospital-items (250)	95	38	37	39

Table 3. Recommendations regarding accreditation, 25 hospitals

Item	Hospitals in which recommended		Number of hospitals applying recommendation
	Number	Percent	
Approval by American Board of Orthopedic Surgery	6	24	[1] 0
Approval by American Board of Pediatrics	3	12	0
Pediatric residency on affiliated basis	4	16	[2] 0
Total hospital-items (75)	13	17	0

[1] Efforts made by 2 hospitals, not yet successful.
[2] Efforts made by 1 hospital, not successful.

Table 4. Recommendations regarding physical plant and equipment, 25 hospitals

Item	Hospitals in which recommended		Hospitals applying recommendation	
	Number	Percent	Number	Percent
Improve outpatient department facilities	6	24	1	17
Improve inpatient facilities	6	24	3	50
Total hospital-items (50)	12	24	4	33

consolidation of the physical location of the orthopedically handicapped children from six different places within the hospital into one central service; provision of a modern operating room, more adequate facilities for physical therapy, and a more suitable plaster room; and removal of an "isolation cubicle" from the children's ward. The recommendations for the outpatient service include: more space in general, more examining space, more space for physical therapy activities, and more privacy for patient examination and interpretation.

Discussion

The results of the first survey of the children's hospital orthopedic services, the transmission of postsurvey recommendations, and the postsurvey conferences may be summarized as follows:

The hospitals put into practice 35 percent of the hospital-items recommended in the area of policies and procedures, more frequently those pertaining to inpatient service than to outpatient service. They adopted 39 percent of the hospital-items recommended in the area of personnel and 33 percent recommended for physical plant improvement. None of the recommendations for accreditation by the American Boards of Orthopedic Surgery and Pediatrics were fully implemented although several hospitals tried.

That this degree of implementation was achieved is gratifying, particularly so because of the apprehension some of the hospital staffs expressed initially about the project. This communitywide survey of the children's hospital orthopedic service was the first in the history of the health department's program. The hospitals may have been apprehensive about the possibility that the New York City Department of Health might withdraw approval, with resultant loss of prestige and funds for patient care and of patient referral.

It was the impression of the survey team, however, that many institutions were genuinely anxious to improve their services. By discussing recommendations frankly, bringing all the medical and nonmedical personnel concerned together, and acquainting them with the suc-

cessful experiences of more efficient services, the team could help the chiefs of service and administrators plan and carry out important basic changes.

Intensive efforts of the survey team members, both as a group and individually, to interpret the purpose of the surveys dispelled some of the concern and apprehension, and the hospital staffs began to realize that the survey team's aim was constructive assistance. An important factor in success or failure of the survey technique and of hospital consultation in general is the interpersonal relationships established between the members of the hospital staffs and the members of the survey team. A friendly working relationship, professional respect, effective interpretation, sincerity, and technical knowledge are the essentials in determining success.

Frequently queried was the reason for the development of the hospital consultation program for handicapped children. The paying agency does have a responsibility in this field, both for helping to improve the care given the children and for guaranteeing to the taxpayer that the tax funds expended are being carefully and justifiably used.

The surveys disclosed several unexpected conditions: (*a*) An unevenness exists in the quality of care given the children by the group of hospitals; (*b*) children are being kept in the New York City hospitals longer than they need to be; and (*c*) more hospitals are approved for the care of orthopedically handicapped children in the New York City program than probably are needed.

Of these three findings, the hospital consultation program has been able to begin to cope with the first two, quality of care and overinstitutionalization. The excess of inpatient beds over the number of children requiring inpatient care is harder to solve. Most of these hospitals have been approved for participation in the orthopedic phase of the handicapped children's program for many years. Withdrawal of long-standing approval is usually difficult.

It is not surprising that more success was achieved in implementing the recommendations for the inpatient than for the outpatient services. In a large urban area the chief of the clinical service and his higher ranking staff usually do not participate personally in the realm of outpatient care. This criticism of outpatient services is not only applicable to the institutions concerned, but it applies equally to the paying agency, which has supported inpatient care but has not yet accepted any financial responsibility for outpatient care. This is a curious policy since most orthopedically handicapped children in the lower income groups receive their medical care through the outpatient service, with only a small percent receiving inpatient care for briefer periods of time. Furthermore, the outpatient service has many roles to play in the care of orthopedically handicapped children—case finding, evaluation, and diagnosis; ongoing medical care and supervision; medical recommendations for special educational placement; and, theoretically at least, some responsibility for the care of the patient at home. Thus, if improvement in the care of orthopedically handicapped children is to progress significantly, outpatient care must be strengthened.

One of the expected findings was that hospital staffs are more immediately able to implement the simpler and more tangible recommendations, for example, improvement of patient records, than the broader and more complex recommendations such as the development of a team concept. While the term "team approach" has been used for many years, nevertheless, it is apparent that the concept has not yet been thoroughly understood in the care of the orthopedically handicapped child. Here, the value of a long-standing effective hospital consultation program can be truly demonstrated since continuing consultation and interpretation will be necessary to motivate the hospital staffs to develop their teams.

That no success was achieved immediately in the area of accreditation by the medical specialty boards is not surprising for several reasons: first, because it takes time for an institution to accomplish this objective, and, second, because there is the knotty problem of supply of approved residency training programs as opposed to the lesser demand for them quantitatively.

It was surprising that in such a brief period of time there was as much implementation of the recommended physical plant and personnel items, the two major areas in which the institution would have to spend the most funds.

Here too, much greater success was achieved in the inpatient than in the outpatient services.

That hospital consultation for orthopedically handicapped children is productive and has achieved some degree of accomplishment, even in its early phases, is clear. The greatest areas in need of further interpretation and strengthening include outpatient care, pediatric care, development of departments of physical medicine and rehabilitation, and the team concept.

REFERENCE

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NRC Medical Research Fellowships

Applications for 1957–58 postdoctoral research fellowships in the medical sciences and radiology are being accepted by the National Research Council until December 1, 1956.

Awarded and administered by the Medical Fellowship Board and the Committee on Radiology of the Division of Medical Sciences, the fellowships include the following groups: national research fellowships in the medical sciences, supported since 1922 by the Rockefeller Foundation; the Donner fellowships for medical research, made possible by a new grant from the Donner Foundation; Markle fellowships in the medical sciences, provided through a new appropriation of the John and Mary R. Markle Foundation; and fellowships in radiological research, administered for the James Picker Foundation.

The first three of these programs offer research in the basic medical sciences for persons seeking careers in academic medicine and investigation. Fellows devote essentially full time to research at the fundamental level. Funds are not available to those wanting to get practical experience in clinical fields.

These awards, open to United States and Canadian citizens holding doctorates in medicine or philosophy or the equivalent, are not ordinarily granted to persons over 35 years of age.

Candidates for the radiological research fellowships must hold the degree of M.D., Ph.D., or Sc.D., or the equivalent. Preference is given to those whose training has been in the field of radiology, but persons from closely related disciplines are eligible to apply. There are no limitations as to citizenship, and the age limit is the same as in the other awards.

The fellowships are awarded in the early spring. Complete details and application blanks may be obtained from: The Division of Medical Sciences, Room 310, National Academy of Sciences-National Research Council, 2101 Constitution Avenue, NW., Washington 25, D. C.

The addition of a chelating agent to water samples examined for pollution may be one answer to the problem of maintaining the coliform index near the level existing when a sample is taken. For periods up to 24 hours, a chelating agent materially reduced the "death rate" of coliform bacteria.

Chelation as a Method for Maintaining the Coliform Index in Water Samples

By E. L. SHIPE, Jr., M.S., and ADELAIDE FIELDS, B.S.

THE POSSIBLE USE of a chemical chelating agent to preserve coliform bacteria in water samples examined for pollution has been explored in a series of experiments by the Tennessee Department of Public Health. Samples of various waters, inoculated with *Escherichia coli*, were tested to determine the rate of decrease in viable cells and the effect of a chelating agent on this rate of decrease.

The coliform bacteria are widely used as indicators of pollution in untreated waters, although at present this practice is a matter of some controversy. Evidence that coliform organisms multiply in waters containing organic matter has been reported by a number of workers, including Caldwell and Parr (*1*), Leahy (*2*), and Mallmann (*3*). However, there appears to be more evidence that the coliform index decreases rapidly during storage of samples, even during storage at low temperatures. Caldwell and Parr (*4*), Cox and Claiborne (*5*), the British Public Health Laboratory Service Water Subcommittee (*6*), and Leininger and McCleskey (*7*) have reported a material decrease of coliforms in samples after storage at various temperatures and for various periods of time.

These reports dealt primarily with temperature and time as factors influencing the decrease in coliforms. It seems reasonable, however, that the presence of certain chemicals in the water might also be a factor. The toxicity of polyvalent metallic ions for *E. coli* has been demonstrated by several workers, including Hotchkiss (*8*) and Fabian and Winslow (*9*). Waters receiving certain industrial wastes may well contain concentrations of metals sufficient to reduce the number of bacteria. A chelating agent added to samples taken from such waters would bind, or complex, any metallic ions present and would thereby prevent their deleterious effect on the bacteria.

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Materials

The chelating agent used in the experiments was Versene Regular, the tetrasodium salt of ethylenediamine tetra acetic acid (EDTA). This compound is one of several powerful amino acids and their salts which are useful as complexing agents for metal ions (*10*). These

acids have the ability to form soluble metal chelate compounds in which the polyvalent metal ion has been bound in a nonionic form. They are nonspecific; that is, they will inactivate practically any metallic ion with which they come in contact.

In a 1.0 percent solution, Versene Regular has a pH of 11.8. In order not to change materially the pH of the test waters, a 10^{-1} stock solution was prepared by combining 1 part Versene Regular with 8 parts double distilled water and 1 part 1N HCl. The pH of this solution was approximately 6.5. The neutralized EDTA 10^{-1} solution was sterilized by autoclaving for 15 minutes at 121° C.

The plating medium used was Bacto-tryptone glucose extract agar.

Escherichia coli ATCC 11229 was the inoculum used. All suspensions were prepared in buffered distilled water diluent (*11*) from cultures grown in nutrient broth for 24 hours at 37° C.

Effect of EDTA on E. coli

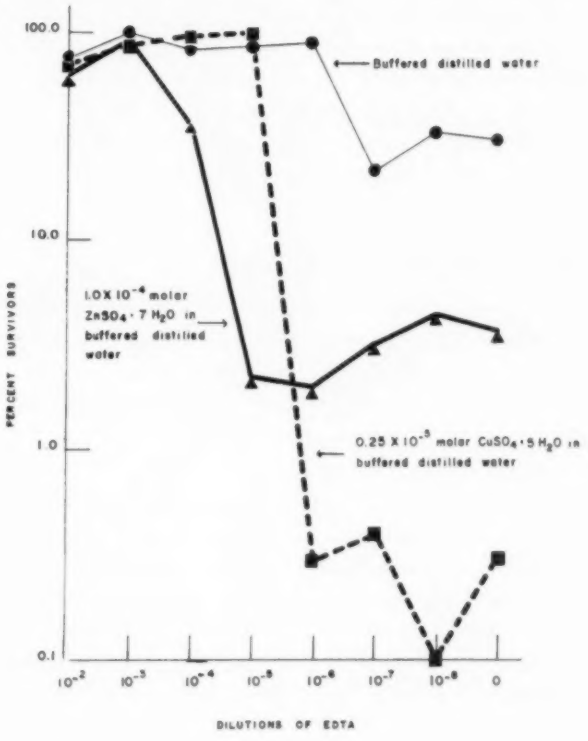
The first in the series of experiments was a study of the effect of the chelating agent on *E. coli*. For this study, varying log dilutions of EDTA in buffered distilled water were prepared. To each of these dilutions, tubed in 9.0-ml. aliquots, was added 1.0 ml. of a diluted cell suspension so that the test dilutions contained 200 to 300 cells per milliliter. These suspensions were kept at 25° C. for 2 hours and then plated to determine the viable cell count.

The light solid line in figure 1 shows the mean result of five trials. The 10^{-3} to 10^{-6} dilutions of EDTA gave a pronounced increase in recovery of cells over the recovery in cell suspensions containing no EDTA, that is, the buffered suspensions. This increase is indicative of an adverse effect of the buffer solution on *E. coli* under these conditions.

Chelation of Polyvalent Metals

The second in the series of experiments was a demonstration of the chelation of polyvalent metallic ions. Varying amounts of EDTA were combined with concentrations of metals known to be toxic to *E. coli* cells, and cells were then added to these chelated solutions.

Figure 1. Effect of EDTA on survival of Escherichia coli in several waters after 2 hours' exposure at 25° C.



Copper and zinc were the metals chosen for this demonstration. Stock solutions of 0.1 molar $CuSO_4 \cdot 5H_2O$ and $ZnSO_4 \cdot 7H_2O$ were prepared using double distilled water. These were further diluted with sterile buffered distilled water so that the final concentrations were 0.25×10^{-5} molar for the copper solution and 1.0×10^{-4} molar for the zinc solution, which correspond to concentrations of 0.16 and 6.5 p.p.m., respectively. These solutions were tubed in 8.0-ml. aliquots. Log dilutions of EDTA from 10^{-1} to 10^{-7} were prepared separately, and 1.0-ml. portions were added serially to the copper and zinc solutions. *E. coli* cell suspensions were added to each of the copper and zinc solutions containing varying amounts of EDTA so that the final cell concentration was approximately 200 to 300 cells per milliliter. These suspensions were held at 25° C. for 2 hours and then assayed for viable cell count.

The dotted line in figure 1 shows the mean result of five trials with the copper solution. The optimum range for chelation of the copper

solutions was 10^{-3} to 10^{-5} dilutions of EDTA. Above the 10^{-5} dilution there was a decided decline in recovery of viable cells because of insufficient EDTA and a resultant copper toxicity.

The mean result of five trials with the zinc solution is shown by the heavy solid line in figure 1. The optimum dilution of EDTA for chelation of zinc appears to be 10^{-3}. A gradual loss in cell recovery occurred as the dilution of EDTA increased.

Effect on Bacterial Death Rates

If fecal pollution enters water containing sufficient quantities of polyvalent metals to result in toxicity to the coliforms, samples collected from this water may well be free of coliforms by the time they reach the laboratory for analysis, even in a matter of a few hours. The addition of EDTA to such samples might interrupt this "death rate" at the time the sample is taken. To investigate this possibility, the following series of laboratory trials was made.

Cell suspensions of *E. coli* containing 2,000 to 3,000 cells per milliliter were prepared. Enough $CuSO_4 \cdot 5H_2O$ solution was added to these suspensions to produce a 0.25×10^{-5} molar (0.16 p.p.m.) solution. Immediately after addition of the $CuSO_4$, 10.0 ml. of the suspension was removed and placed in a tube containing 0.1 ml. of 10^{-1} dilution of EDTA. This tube was held at 25° C. for later analysis. After 10 minutes another 10 ml. was removed from the original suspension and added to a tube containing 0.1 ml. of the 10^{-1} dilution of EDTA. This was immediately assayed for viable cell count, and the remainder was held at 25° C. for subsequent analysis. Samples were taken at 20, 30, 60, and 120 minutes and treated as the sample taken at 10 minutes. All chelated samples were reassayed after 2 hours at 25° C. and again after 24 hours at the same temperature.

Figure 2. Effect of EDTA on rate of decrease in Escherichia coli in 0.25×10^{-5} molar (0.16 p.p.m.) $CuSO_4 \cdot 5H_2O$ buffered distilled water.

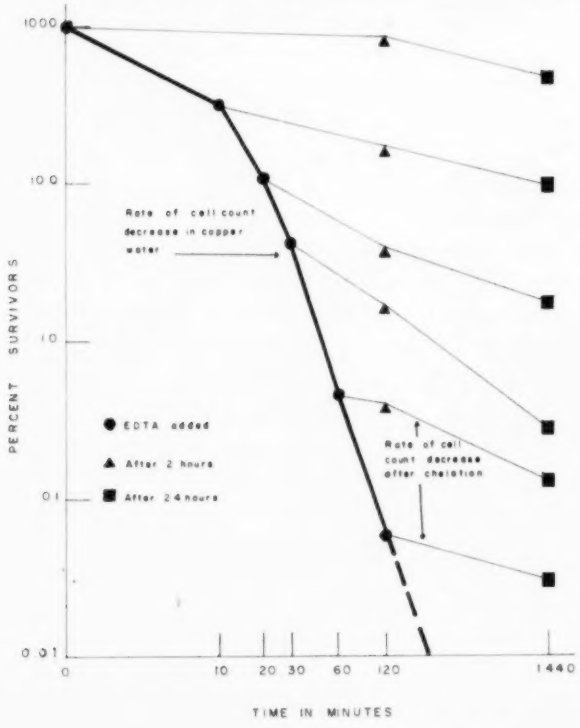
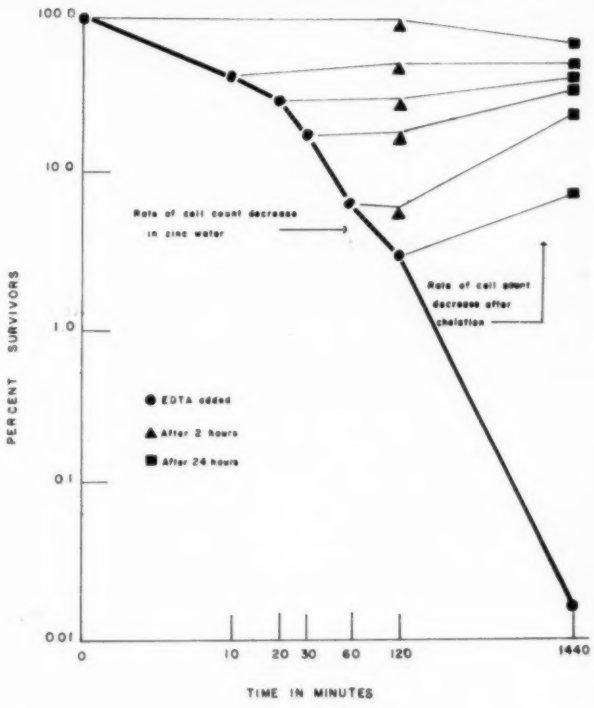


Figure 3. Effect of EDTA on rate of decrease in Escherichia coli in 1.0×10^{-4} molar (6.5 p.p.m.) $ZnSO_4 \cdot 7H_2O$ in buffered distilled water.



Similar trials were performed with a zinc solution, using 1.0×10^{-4} molar (6.5 p.p.m.) $ZnSO_4 \cdot 7H_2O$ as the final concentration of zinc.

Since buffered distilled water had shown an adverse effect over a 2-hour period, it was included in this study. Deionized (Crystalab Deeminizer) distilled water was also included. Samples of these waters were chelated at the various time intervals described.

Ten trials were performed for each water tested.

In figure 2 the loss of viable cells exposed to copper is shown by the heavy line. The circles indicate the viable cell count at the time of chelation with EDTA; the triangles, the count in the chelated suspension after a period of 2 hours' exposure; and the squares, the count after 24 hours' exposure.

In an unchelated sample, the cells in the suspension apparently die off shortly after 2 hours' exposure. In the 2-hour samples, the rate of cell count decrease was definitely changed by the addition of EDTA. As exposure to copper continued, the slope of the line increased from time of chelation to the 2-hour period. This indicates that as exposure continues progressive damage may be done to the cells which cannot be overcome by chelation. The slope from 2 hours to 24 hours was about the same for all of the time intervals.

Figure 3 shows similar data for the zinc solution. Chelation of zinc apparently holds the count at approximately the same level as it is at the time of chelation. From the 24-hour samples, it can be surmised that some of the cells recover after standing in EDTA, or else the remaining cells are stimulated to multiply to a slight degree.

Figure 4. Effect of EDTA on rate of decrease in Escherichia coli in buffered distilled water.

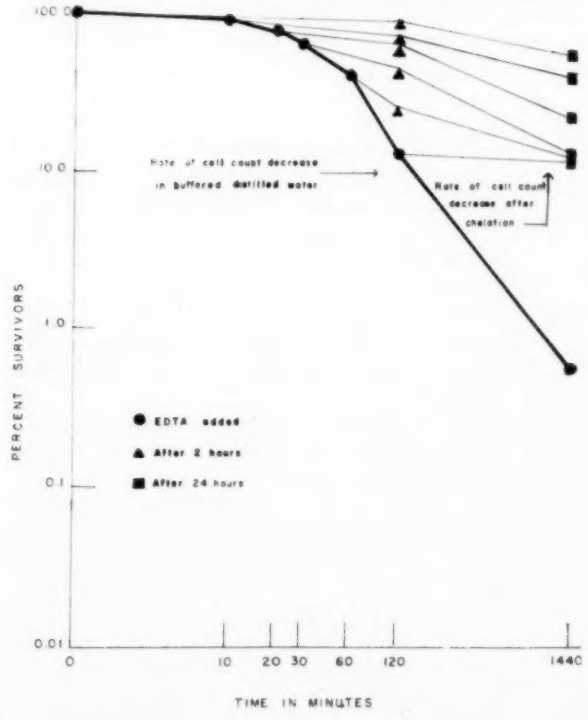


Figure 5. Effect of EDTA on rate of decrease in Escherichia coli in deionized distilled water.

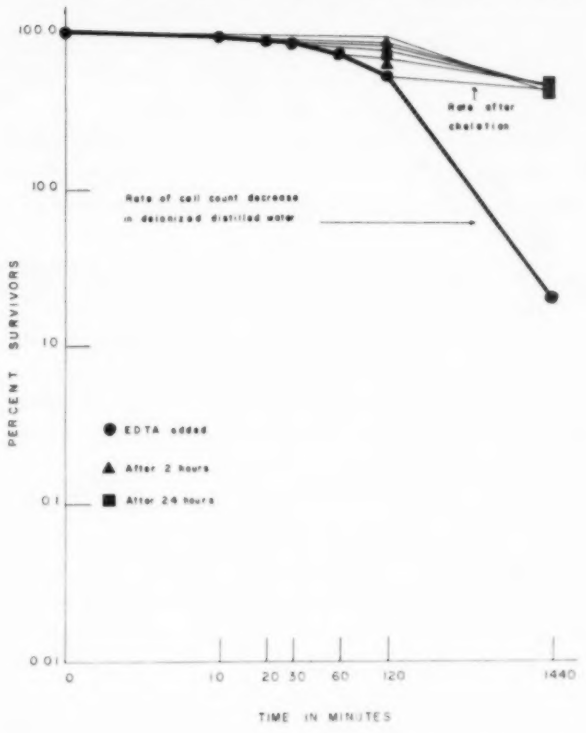


Figure 4 shows the results obtained when buffered distilled water was used as a suspending fluid. EDTA is apparently effective in reducing the rate of decrease in *E. coli* cells in buffered distilled water void of added metals.

In figure 5 are shown the data for the deionized water. This material had the lowest "bacterial death rate" of any of the waters tested. Even so, the addition of EDTA to deionized water resulted in an improved recovery, possibly because of an osmotic pressure difference more favorable to the cells than deionized water.

The mean pH of the waters tested was 6.87 ± 0.13.

Discussion

These experiments have shown a rate of decrease in *E. coli* cells suspended in various waters. Waters containing small amounts of

metals, 0.16 p.p.m. of copper or 6.5 p.p.m. of zinc, were the most deleterious tested. Even buffered distilled water was responsible for loss of approximately 99.7 percent of the cells within a 24-hour period. In deionized water 98.0 percent of the cells were gone within 24 hours.

EDTA in dilutions of 10^{-2} to 10^{-6} was found to be nontoxic for *E. coli* cells. Greater dilutions were of no value in maintaining cell viability.

The Public Health Service Drinking Water Standard sets 3.0 mg. per liter (3.0 p.p.m.) as the upper limit for copper and 15.0 mg. per liter (15 p.p.m.) as the upper limit for zinc (*11*). Both of these limits exceed the amounts of these metals used in our experiments. Copper and zinc in the quantities used were shown to increase materially the rate of cell count decrease of *E. coli* as compared with the rate for buffered or deionized distilled water. Addition of EDTA to samples of these waters, taken at various time intervals, resulted in a reduced rate of decrease in the cell count, the amount of reduction depending upon the time the sample was taken. For example, in a sample from water containing copper (0.16 p.p.m.) the percentage of survivors was reduced to 0.08 after 2 hours and to approximately zero shortly thereafter. The addition of EDTA at the time of sampling resulted in approximately 69.0 percent of the cells remaining viable after 2 hours and 40.0 percent after 24 hours. Similar increased recovery was shown for the other waters tested.

Several trials, not described in this report, have been run on samples of rural water supplies. In some samples, the addition of EDTA seemed to promote growth of the coliforms when the samples were stored at 25° C., whereas without EDTA, there was a decrease in numbers of cells during storage. This effect of EDTA, of course, has its disadvantages, in that it tends to give an overestimation of coliform density. On the other hand, would it not be better to find positive those water sources that previously have been reported negative because of a loss of viable cells from the time the sample was taken until it was tested in the laboratory than to report them as safe supplies? The addition of EDTA to samples might be of value in the isolation of enteric pathogens from waters. Studies of this possibility are now being undertaken in this laboratory.

Summary and Conclusion

In laboratory experiments by the Tennessee Department of Public Health, the addition of the chelating agent ethylenediamine tetra acetic acid to samples of various waters (water containing copper or zinc, buffered distilled water, and deionized water) materially reduced the rate of decrease in *Escherichia coli* cells. It appears that, for periods up to 24 hours, chelating agents would be of value in maintaining the coliform index near the level existing at the time the sample is taken.

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Susceptibility of New Mexico Rodents to Experimental Plague

By R. HOLDENRIED, Ph.D., and S. F. QUAN, Ph.D.

DURING the last three decades, extensive studies have been made to elucidate the plague vector capacity of many flea species infesting wild rodents (*1*). On the other hand, there has been a lack of adequate investigation concerning the susceptibility to *Pasteurella pestis* infection of the wild rodent hosts of these fleas. Until both factors, vector potential and host susceptibility, are determined, the ecology of sylvatic plague will be difficult to understand. A flea whose natural host is refractory to the development of *P. pestis* bacteremia is unlikely to be a plague vector.

In the early laboratory studies of the susceptibility of wild rodents to *P. pestis*, McCoy (*2*, *3*) and McCoy and Smith (*4*) established that several species of animals succumbed to experimental infection. Subsequently, other rodents of these species were found in the field infected from natural sources. Although these investigators produced infection in seven species of rodents, the relative susceptibility of these animals to plague infection could not be evaluated from their data because the number of bacteria either injected or introduced by skin scarification was not recorded. But a rough comparison of species susceptibility was presented. For example, all 19 inoculated California ground squirrels (*Citellus beecheyi*) died of plague while only 8 of 15 inoculated valley pocket gophers (*Thomomys bottae*) died, an indication that of these 2 species the ground squirrel was more susceptible.

Later, from an extensive series of investigations on California ground squirrels, Meyer (*5*) concluded that young squirrels were more susceptible than adults; adult males were more susceptible than adult females; squirrels from a known plague focus were more resistant to infection than were squirrels from a plague-free area.

For detailed comparisons of the susceptibility of various animal species to plague, Meyer's work indicated the need for considering the plague history of the area supplying the experimental animals, as well as their age and sex.

With this background, the ecology of wild rodents and their ectoparasites was studied at the Santa Fe Field Station of the Communicable Disease Center, Public Health Service.

Dr. Holdenried, a senior scientist, and Dr. Quan, a medical bacteriologist, are with the Public Health Service's Communicable Disease Center, San Francisco Field Station in California. At present, Dr. Holdenried is detailed to the Dugway Proving Ground, Chemical Corps Research and Development Command, Dugway, Utah. During the time of this study, Dr. Holdenried was chief of the Santa Fe Field Station in New Mexico, and Dr. Quan was on temporary duty at the station. *The New Mexico State Health Laboratory at Albuquerque provided use of its facilities and certain materials.*

We present here the results of testing locally trapped adult rodents for susceptibility to experimental plague.

Procedure

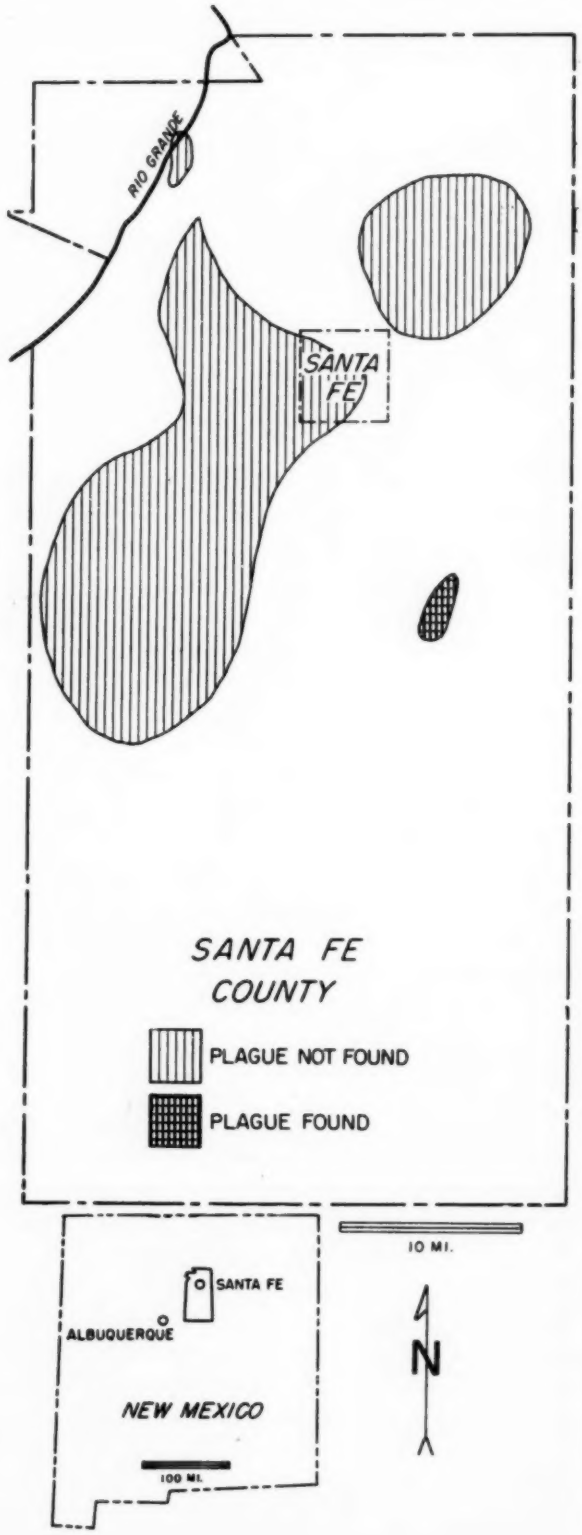
Test animals were trapped between September 21 and December 17, 1953. After a liberal dusting with pyrethrum powder to kill their fleas, the rodents were held in the Santa Fe laboratory for testing between October 21 and December 18, 1953.

The inoculum was obtained from 24-hour cultures of *P. pestis*, Alexander strain, New Mexico (*6*), grown at approximately 28° C. in brain-heart infusion broth and in dilutions of the broth varying from 10^{-1} to 10^{-8} in 1 percent peptone water. The number of viable organisms in an inoculum was calculated from the counts of the bacterial colonies, obtained by spreading on each of several blood-agar plates 0.2 ml. portions of 10^{-6} and 10^{-7} dilutions of the culture and allowing the bacteria on these agar plates to grow for 2 days in a 28° C. incubator. White laboratory mice, Princeton strain, inoculated with dilutions of the cultures, served as susceptible controls.

Each rodent in the experiments received initially 0.05 ml., inoculated intracutaneously into a shaven area over the right thigh. Intracutaneous inoculations were used on the assumption that they simulate infection by flea bites more closely than either subcutaneous or intraperitoneal inoculations. Some survivors of the initial injection were reinoculated intracutaneously 17 days after the first inoculation. A few survivors of the second injection were inoculated a third time. This was done intraperitoneally with 0.5 ml. of undiluted culture 41 days later.

On death, animals were autopsied. Evidence that plague was the cause of death was obtained from microscopic examination of stained smears of lymph nodes, spleen, liver, or heart blood exhibiting the typical bipolar bacillus; from appropriate macroscopic pathology; and from plague organisms identified on blood-agar culture of tissue smears. Tissues from test animals failing to show plague by one or more of these three processes were subinoculated by scar-

Areas in Santa Fe County, N. Mex., from which rodents were collected for susceptibility tests to experimental plague infection.



ification into mice. On death, the subinoculated mice were subjected to the same procedure followed for the test animals.

To investigate the possible development of latent infections, some of the animals that had survived at least 21 days after inoculation were sacrificed. Their spleen, liver, and, if present, enlarged lymph nodes, were pulped and inoculated into guinea pigs or mice.

Eleven rodents that survived previous inoculations were inoculated intraperitoneally with 0.5 ml. of plague toxins prepared according to the method used by Quan and associates (*7*) and Goodner and associates (*8*).

Results and Discussion

A total of 398 wild rodents of 21 species and 105 white control mice were inoculated with varying numbers of plague organisms. The wild rodent species ranged in susceptibility to infection from being as uniformly sensitive as the control mice to complete refractoriness. The LD_{50} for the laboratory mouse was about 7 bacilli.

The species found as homogeneously susceptible as the control strain of laboratory mouse were:

Reithrodontomys megalotis aztecus Allen, western harvest mouse
Perognathus flavus flavus Baird, silky pocket mouse
Peromyscus leucopus tornillo Mearns, white-footed mouse
Peromyscus truei truei (Shufeldt), piñon mouse
Neotoma albigula albigula Hartley, whitethroat woodrat
Neotoma mexicana fallax Merriam, Mexican woodrat
Eutamias minimus operarius Merriam, least chipmunk (probably as susceptible)

Although some individuals of the following species were resistant, the majority died of plague after infection with 1 to 1,000 mouse LD_{50}:

Peromyscus maniculatus rufinus (Merriam), deer mouse
Peromyscus boylii rowleyi (Allen), brush mouse
Peromyscus nasutus nasutus (Allen), rock mouse
Neotoma micropus canescens Allen, southern plains woodrat
Eutamias quadrivittatus quadrivittatus (Say), Colorado chipmunk

Those moderately resistant to infection (more than 1,000 mouse LD_{50}) were:

Citellus variegatus grammurus (Say), rock squirrel
Citellus spilosoma marginatus Bailey, spotted ground squirrel
Microtus longicaudus mordax (Merriam), longtail vole
Onychomys leucogaster pallescens Merriam, northern grasshopper mouse
Thomomys bottae nervagus Merriam, valley pocket gopher
Thomomys talpoides fossor Allen, northern pocket gopher

On the other hand, the following were refractory to intracutaneous inoculations of about a million mouse LD_{50}:

Dipodomys spectabilis baileyi Goldman, bannertail kangaroo rat
Dipodomys ordii medius Setzer, Ord kangaroo rat

The number of rodents in each species dying of plague after the experimental infection and the total number of rodents inoculated at each dilution are tabulated as fractions in tables 1 and 2.

Reithrodontomys megalotis aztecus and *Perognathus f. flavus* were more susceptible to experimental plague infection than were the white mice controls. The five species of *Peromyscus* were quite susceptible and succumbed to about the same number of organisms required to kill the controls, but certain individuals of both *P. maniculatus rufinus* and *P. n. nasutus* showed a fairly high degree of resistance. None of the three species of *Neotoma* survived inoculation of 10,000 organisms, but a few survived doses of less than 10 organisms. Reinoculated *Neotoma* survivors succumbed to 1,000 organisms. It was found that the diluted bacterial suspension initially inoculated into these animals was noninfectious. *Microtus*, *Citellus*, and *Eutamias* appeared to be more resistant than the *Neotoma*.

Thomomys and *Onychomys* showed a high degree of resistance, especially upon reinoculation. This may have been the result of an immunizing effect of the first inoculation. Two *Thomomys* that survived two previous intracutaneous inoculations succumbed to 100 million organisms inoculated intraperitoneally. Both species of *Dipodomys* were amazingly resistant

Table 1. Number of rodents dying of plague per number inoculated with varying numbers of Pasteurella pestis organisms

Rodent species	Original inoculation									First reinoculation [1]			
	10^7	10^6	10^5	10^4	10^3	10^2	10	1–5	<1	10^7	10^5	10^4	10^3
White mice controls [2]	----	6/6	6/6	16/17	17/17	15/16	14/16	4/16	0/11	----	----	----	----
Reithrodontomys megalotis aztecus	----	----	----	4/4	----	----	----	4/4	----	----	----	----	----
Perognathus flavus flavus	----	----	----	1/1	----	----	----	3/3	----	----	----	----	----
Peromyscus boylii rowleyi	----	----	----	5/6	----	----	----	5/5	----	----	----	1/1	----
Peromyscus leucopus tornillo	----	----	----	5/5	9/9	10/10	9/11	6/14	----	----	----	0/1	----
Peromyscus maniculatus rufinus	----	5/6	----	9/10	6/7	12/15	8/8	6/17	----	----	0/5	----	----
Peromyscus nasutus nasutus	----	----	----	6/7	----	----	----	3/5	----	----	----	2/2	----
Peromyscus truei truei	----	----	4/4	19/19	16/16	16/16	13/16	1/3	----	----	----	2/2	----
Neotoma albigula albigula	----	----	----	7/7	4/4	----	5/8	6/11	0/2	----	----	----	----
Neotoma mexicana fallax	----	----	----	4/4	----	----	1/1	3/6	1/2	----	----	----	2/2
Neotoma micropus canescens	----	----	----	6/6	----	----	2/3	4/8	0/3	----	----	----	2/2
Eutamias minimus operarius	----	----	----	6/6	1/1	----	----	4/6	----	----	----	----	2/2
Eutamias quadrivittatus quadrivittatus	----	----	----	3/4	----	----	----	3/5	----	----	3/3	----	----
Citellus lateralis lateralis	----	----	2/2	----	----	----	----	----	----	----	----	----	----
Citellus spilosoma marginatus	----	----	----	3/4	----	----	----	3/4	----	----	1/2	----	----
Citellus variegatus grammurus	----	----	----	3/5	----	----	----	0/4	----	----	4/6	----	----
Microtus longicaudus mordax	----	----	----	4/5	0/6	----	----	1/4	----	----	2/4	----	----
Onychomys leucogaster pallescens	1/1	----	----	1/4	----	----	----	0/5	----	2/4	1/4	----	----
Thomomys talpoides fossor	1/1	----	0/1	0/3	----	----	----	0/4	----	2/7	----	----	----
Thomomys bottae nervagus	----	----	0/2	----	----	----	----	----	----	----	----	----	----
Dipodomys ordii medius	0/2	0/2	0/4	0/9	----	----	----	0/5	----	0/10	----	----	----
Dipodomys spectabilis baileyi	0/2	----	0/3	0/4	----	----	----	0/4	----	0/7	----	----	----

[1] First reinoculation given 17 days after the original.
[2] Albino mice controls for all experiments.

to infection. None died upon intracutaneous inoculations of as many as 10 million organisms, but some succumbed to 100 million organisms inoculated intraperitoneally.

The number tested in each rodent species was insufficient to indicate possible variation in susceptibility between sexes and different ages. The lack of an opportunity to experiment at another time than the October–December period leaves unanswered the possibility that there may be a seasonal change in host receptiveness to infection.

Following the completion of the plague susceptibility experiments some of the surviving rodents were injected with plague toxins. Each of these animals received a toxic dose equivalent to 600 times the LD_{50} for white laboratory mice. Each of two *Onychomys* receiving toxins died. The two *Thomomys*, one each of species *talpoides* and *bottae*, also succumbed. Three of the four *Dipodomys ordii medius* and one of three *Dipodomys spectabilis baileyi* were killed. All deaths occurred within 24 hours after the injection of poisons. The controls for each species survived for more than 3 weeks.

For four species of the rodents, the susceptibility to *P. pestis* of rodents from a plague-free area was compared with that of animals trapped in an area in which plague-positive rodents and fleas had been found (*9*). The map shows the proximity of the two areas. No difference was observed in the degree of susceptibility of the two sets of rodent species, *Neotoma a. albigula*, *Peromyscus t. truei*, *Peromyscus leucopus tornillo*, and *Peromyscus maniculatus rufinus* (table 2). These results contrast with the observations made by Meyer (*5*) on California ground squirrels. The reasons for these contrasting observations are not readily apparent. It is possible that the animals trapped in the plague-focus area were from populations without previous plague experience. Actual geographic limits of the plague focus could not be delineated, and no evidence could be found to substantiate an assumption that the infection spread throughout the trapping area. The difference between Meyer's observations and those in the present study may possibly be explained by the different species of hosts used.

The mortality indexes of four rodent species

(table 2) are shown in table 3. The mortality index (*10*) is the ratio of the percent mortality to the average survival time in days and is identical to the mouse protective index as originally used by Meyer and Foster (*11*) to evaluate human serum with mice. The mortality index for the species of rodents that were homogeneously susceptible to infection varied directly with the dose of the infecting inoculant, whereas the index for the heterogeneously responding species (*P. maniculatus rufinus*) did not. The calculated range of the 95 percent fiduciary probability is well within the observed results.

Three *P. maniculatus rufinus* yielded tissues infected with *P. pestis* 25 to 34 days after they received their last inoculation. These animals showed no obvious signs of illness prior to the time they were sacrificed. The significance of the recovery of virulent *P. pestis* in tissues of apparently healthy mice, 5 weeks after inoculation, is not known. Obviously, the ultimate fate of the infecting organisms, had the mice continued to live, could not be determined. Of all the species tested, only *P. maniculatus rufinus* was found to harbor the organisms while remaining alive in apparent good health.

Olitzki (*12*) recently reported the isolation of plague bacilli from the spleen of *Microtus guentheri* and from the abscess at the inoculation site 6 weeks after the subcutaneous injection of 1 million bacteria. At the George Williams Hooper Foundation, University of California, Quan (unpublished data) recovered virulent *P. pestis* from apparently healthy

Table 2. Comparison of susceptibility to experimental plague in rodents from plague and nonplague foci: number of rodents dying per number inoculated with varying numbers of Pasteurella pestis organisms

Rodent species [1]	Original inoculation								First reinoculation	
	10^6	10^5	10^4	10^3	10^2	10	1–5	<1	10^5	10^4
Neotoma albigula albigula:										
Plague focus			3/3	4/4		3/5	2/5			
Plague free			4/4			2/3	4/6	0/2		
Peromyscus truei truei:										
Plague focus			6/6	6/6	6/6	6/6				
Plague free		4/4	13/13	10/10	10/10	7/10	1/3			2/2
Peromyscus leucopus tornillo:										
Plague focus				4/4	5/5	5/5	1/5			
Plague free			5/5	5/5	5/5	4/6	5/9			0/1
Peromyscus maniculatus rufinus:										
Plague focus	5/6		6/6		5/6		0/5			
Plague free			3/4	6/7	7/9	8/8	6/12		0/5	

[1] Species totals for plague-free and plague-focus areas are shown in table 1.

Table 3. Mortality indexes according to number of Pasteurella pestis inoculated and LD_{50} doses of four rodent species and control mice

Rodent species	Mortality index [1]					LD_{50} [2]	
	10^4	10^3	10^2	10	<10	Dose	95 percent fiducial limits
Neotoma albigula albigula		33. 3	26. 4	12. 9	10. 0	2. 6	1. 1–5. 8
Peromyscus truei truei	36. 4	33. 3	32. 8	29. 1	16. 7	2. 8	1. 3–6. 2
Peromyscus leucopus tornillo		28. 6	31. 3	25. 7	9. 1	3. 8	2. 0–7. 2
Peromyscus maniculatus rufinus	17. 0	25. 7	19. 8	6. 2	0	38. 0	1. 4–2040
White control mice	32. 2	27. 0	20. 6	17. 6	7. 6	7. 0	4. 0–10. 0

[1] Percent mortality per average life of rodents that died (in days); same as mouse protective index used by Meyer and Foster (*11*).

[2] Method of Litchfield and Wilcoxon (*10*).

guinea pigs killed more than 30 days after inoculation. Although recovery of virulent microorganisms from apparently healthy animals, 4 to 6 weeks after inoculation, may suggest how the plague bacillus could be maintained in wild rodents during interepizootic periods, this finding cannot be regarded as latent plague (*13*, *14*) without proof that disease will finally occur (*15*).

Summary

A total of 398 wild rodents of 21 species were inoculated intracutaneously with 0.05 ml. of aqueous suspensions containing various numbers of *Pasteurella pestis* (Alexander strain, New Mexico) to test their susceptibility to plague infection in comparison with white laboratory mice inoculated identically.

The wild rodent species ranged in susceptibility from homogeneous sensitivity equal to that of the control mice to complete resistance.

The majority of the rodents that survived plague inoculation, regardless of species, died of toxemia after receiving about 650 LD_{50} of plague toxins intraperitoneally.

The comparison of four species, *Neotoma albigula albigula*, *Peromyscus truei truei*, *Peromyscus leucopus tornillo*, and *Peromyscus maniculatus rufinus*, trapped in an area where plague was found with those collected from a plague-free area, demonstrated no differences in susceptibility to experimental *P. pestis* infection.

Since the available number of animals of any one species tested was small, such factors as sex and age could not be evaluated.

The possible effect of seasons on the susceptibility of the rodents was not investigated. The persistence of plague in the area where it occurred was not determined.

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General Hospital and Nursing Home Beds in Urban and Rural Areas

By JERRY SOLON, M.A., and ANNA MAE BANEY, B.A.

HOSPITAL and other medical facilities are distributed in particular patterns. Understanding the existing distribution patterns and the factors producing or accompanying them is an important step toward planning for facilities properly distributed to meet health needs.

This report analyzes the relative availability of general hospital and nursing home beds in terms of counties classified according to their urban or rural character. Within this framework it examines the distribution of beds in relation to per capita income, proportion of older people, and supply of medical personnel. This approach permits a more detailed examination of rural-urban differences than was possible through analysis of such differences based on general hospital service areas (*1*).

The study is based in part on data on general hospitals submitted for 1953 in State hospital plans for the Hospital Survey and Construction (Hill-Burton) Program. Information on skilled nursing homes was obtained in a 1954 national survey conducted by the Public Health Service. Detailed explanation of these and other data used in this report is given in Public Health Monograph No. 44.

Urban-Rural Classification

For the purpose of identifying the existing distribution patterns of beds in general hospitals and nursing homes, the county is a useful analytical unit, although it does not necessarily constitute a "trading area" in actual use of health facilities. However, ready statistical information pertaining to population and socioeconomic characteristics is available on a county basis. It is through correlation with such information that the distribution patterns of medical resources become understandable.

Public Health MONOGRAPH

No. 44

The accompanying article supplements and reexamines, from another avenue of approach, the ground covered in Public Health Monograph No. 44, published concurrently with this issue of Public Health Reports. The monograph analyzes the availability of general hospital and nursing home beds in the framework of general hospital "service areas," which correspond to trading areas for hospital services. The authors are health program analysts with the Division of Hospital and Medical Facilities, Public Health Service.

Readers wishing the more extensive analysis may purchase copies of the monograph from the Superintendent of Documents, Government Printing Office, Washington 25, D. C. A limited number of free copies are available to official agencies and others directly concerned on specific request to the Public Inquiries Branch of the Public Health Service. Copies will be found also in the libraries of professional schools and of the major universities, and in selected public libraries.

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Solon, Jerry, and Baney, Anna Mae: General hospitals and nursing homes: Patterns and relationships in their geographic distribution. Public Health Monograph No. 44 (Public Health Service Publication No. 492). 56 pages. Illustrated. U. S. Government Printing Office, Washington, D. C., 1956. Price 40 cents.

The county classification system used here was first developed in the 1946 American Academy of Pediatrics study of child health services (*2*) and was brought up to date on the basis of 1950 data by Pennell and Altenderfer (*3*). In this classificatory scheme, size of population and nearness to densely populated areas determine the designation of each county as:

Greater metropolitan. Counties included in any one of 14 "standard metropolitan areas" of 1,000,000 population or more. A "standard metropolitan area" consists of a county, or group of adjoining counties, which forms an integrated economic and social unit around a central city or cities of 50,000 or more (*4*).

Lesser metropolitan. Counties included in "standard metropolitan areas" of less than 1,000,000 population.

Adjacent. Counties that touch a metropolitan county as defined above.

Isolated semirural. Any other county containing at least one incorporated place of 2,500 or more population.

Isolated rural. Counties having no incorporated community of 2,500 or more.

This urban-rural characterization of counties has an especially significant application to the manner in which medical facilities are distributed. The metropolitan and adjacent counties represent areas served by, or readily accessible to, medical facilities available in larger urban centers. The isolated counties, however, do not have easy accessibility to a metropolitan center and are therefore usually limited to the generally less comprehensive medical services which can be secured locally.

Table 1 shows the number of counties in each of the urban-rural categories and the corresponding distribution of population. One-third of the counties in the United States, those identified as metropolitan and adjacent, with nearly three-fourths of the population, are accessible to the medical resources concentrated in large urban centers. The remaining two-thirds of the counties, designated as isolated, with about one-fourth of the population, are comparatively remote from the medical facilities of metropolitan centers.

Distribution of Beds

Metropolitan counties have the most general hospital beds, averaging over 4 per 1,000 population (table 2). Isolated rural counties have the fewest, with an average of less than 2 per 1,000 population.

Isolated semirural counties have relatively more general hospital beds (3.8 per 1,000 population) than do counties adjacent to metropolitan areas (2.8 per 1,000). Obviously, the location of a county adjacent to metropolitan medical services reduces the need for beds in the county proper.

Beds in skilled nursing homes show a somewhat different pattern of distribution (table 2). Metropolitan and adjacent counties have, proportionately, about equal numbers of nursing home beds (average of 1.3 to 1.4 per 1,000 population). The availability of nursing home beds diminishes as the counties become more rural (isolated semirural counties, 0.9 per 1,000 population, and isolated rural counties, 0.4 per 1,000).

Table 1. Distribution of counties and their population by urban-rural character of county, 1950

Character of county	Number of counties	Population	Percentage distribution	
			Counties	Population
All counties	3,076	150,697,361	100.0	100.0
Metropolitan and adjacent	**1,020**	**109,272,372**	**33.2**	**72.5**
Greater metropolitan	71	44,946,386	2.3	29.8
Lesser metropolitan	204	40,631,787	6.6	27.0
Adjacent	745	23,694,199	24.2	15.7
Isolated	**2,056**	**41,424,989**	**66.8**	**27.5**
Semirural	1,160	33,177,227	37.7	22.0
Rural	896	8,247,762	29.1	5.5

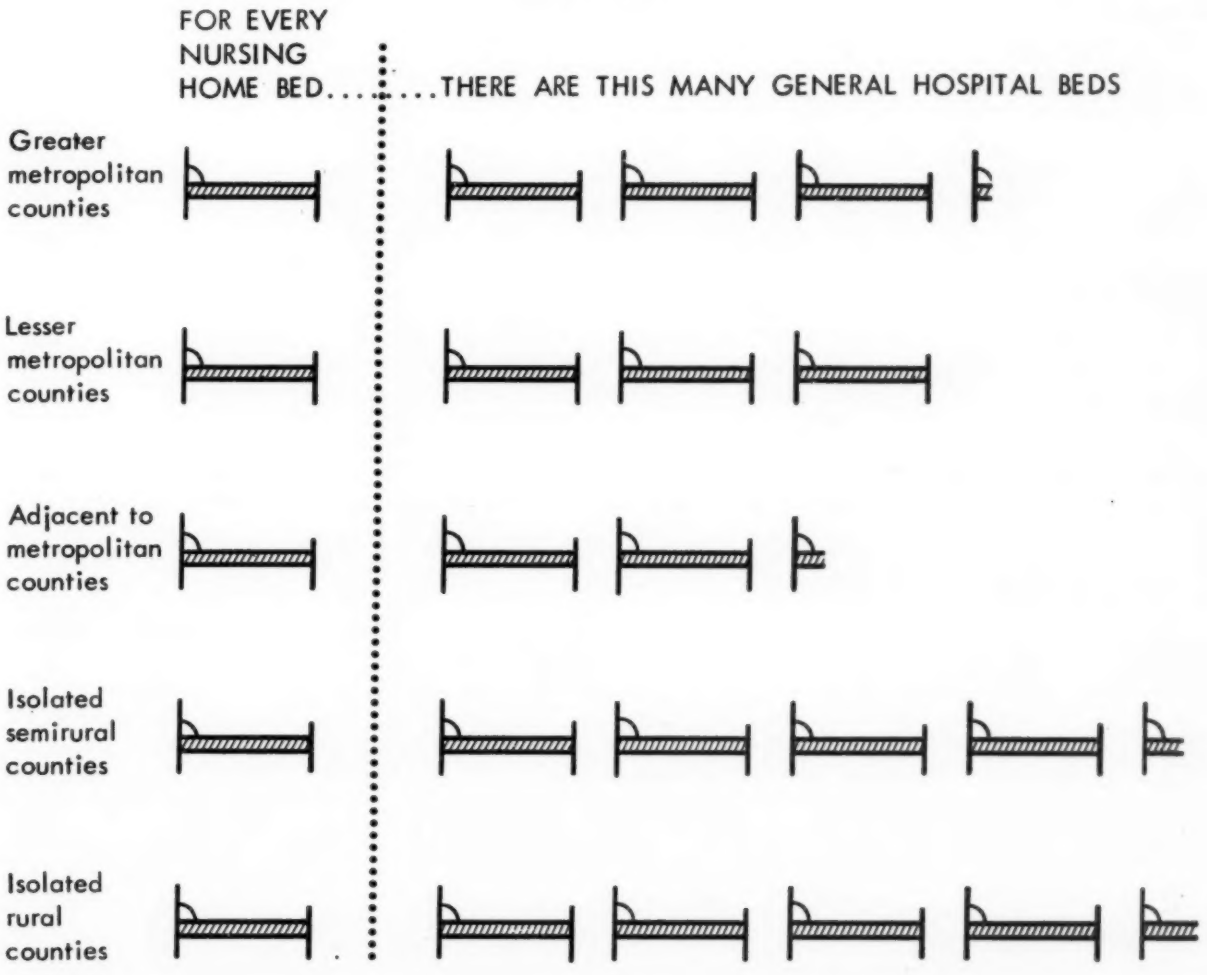
SOURCE: Based on data in reference 3.

Table 2. Availability of beds in general hospitals and skilled nursing homes, by urban-rural character of county

Character of county	Number of beds		Beds per 1,000 population [2]	
	General hospitals, 1953	Nursing homes, 1954 [1]	General hospitals	Nursing homes
All counties	564, 826	180, 000	3. 7	1. 2
Metropolitan and adjacent	**425, 168**	**147, 700**	**3. 9**	**1. 4**
Greater metropolitan	185, 738	59, 800	4. 1	1. 3
Lesser metropolitan	172, 524	58, 000	4. 2	1. 4
Adjacent	66, 906	29, 900	2. 8	1. 3
Isolated	**139, 658**	**32, 300**	**3. 4**	**. 8**
Semirural	125, 042	29, 000	3. 8	. 9
Rural	14, 616	3, 300	1. 8	. 4

[1] Partly estimated, based on actually reported 6,531 homes and 171,106 beds.
[2] Based on 1950 population, as shown in table 1. Ratios derived from sums of populations and beds of counties in respective groups.

Figure 1. Ratio of general hospital beds to skilled nursing home beds, by urban-rural character of county, 1953–54.



Nationally, there is one skilled nursing home bed for every 3.3 general hospital beds. Figure 1 expresses the relationship between the availability of general hospital beds and skilled nursing home beds in the several types of counties. One skilled nursing home bed is available in metropolitan counties for every 3.0 general hospital beds; in adjacent counties, for every 2.2; and in isolated counties, for every 4.3 general hospital beds.

Areas surrounding metropolitan counties thus are comparatively favored in the location of nursing homes. They maintain proportionately as many nursing home beds as do the neighboring metropolitan counties, on an average, although their supply of general hospital beds is much below that of the metropolitan counties. This suggests a differential geographic pattern of development between general hospitals and nursing homes. The greater concentration of both hospitals and nursing homes in urban areas as opposed to rural areas may be explained in large part on the basis of economic factors. Nursing homes, in addition, have developed to a greater extent in urban areas as a consequence of the distinctive housing and family living arrangements characteristic of cities. They have, however, gravitated largely to the fringes of the cities, whereas hospitals have tended to be centrally located. Differential land values have been a strong factor in inducing nursing homes to locate away from expensive in-city sites, particularly in seeking larger tracts of land to provide some grounds around the home. This phenomenon has probably come about through the conversion to nursing homes of certain types of residences typically found in more outlying residential areas.

All of the patterning observed in the foregoing data represent central tendencies within a wide range of bed availability. In fact, among themselves, the counties of any one urban or rural type show a broad range of availability of beds.

Interrelationship in Availability of Beds

As we have noted in treating each of the types of counties as a whole, the distributions of beds in general hospitals and nursing homes are similar in some respects and dissimilar in others. Of further interest is the question of how the relative volumes of beds correspond within individual counties.

Table 3 presents the average availability levels of beds in skilled nursing homes for counties with different levels of supply of general hospital beds. Despite some tendency for levels of nursing home beds to increase with increasing supplies of general hospital beds, many departures from such a pattern occur. Furthermore, the counties represented within any one group by the given bed ratio are actually quite dispersed in their individual ratios. (The low degree of correspondence between the county supply levels of beds in general hospitals and nursing homes is reflected in a simple correlation coefficient of .09.)

Table 3. Relative availability of beds in skilled nursing homes, by level of availability of beds in general hospitals within each urban-rural county type, 1953–54

General hospital beds per 1,000 population in county	Average nursing home beds per 1,000 population					
	All counties	Greater metropolitan	Lesser metropolitan	Adjacent to metropolitan	Isolated semirural	Isolated rural
Total	1.2	1.3	1.4	1.3	0.9	0.4
None	0.8	2.2	1.0	0.9	0.6	0.5
Less than 1.0	.4	.6	.7	.8	.1	.1
1.0–1.9	.8	1.0	1.3	1.0	.5	.3
2.0–2.9	1.0	1.1	.9	1.2	.7	.5
3.0–3.9	1.2	1.3	1.2	1.4	.8	.3
4.0–4.9	1.4	1.4	1.5	1.7	.9	.3
5.0–5.9	1.1	.9	1.5	1.0	1.3	.1
6.0–6.9	1.3	1.6	1.4	1.3	1.1	.2
7.0 and over	1.4	1.5	1.5	1.4	1.1	.2

Table 4. Availability of beds in general hospitals and skilled nursing homes, by per capita income of county, by urban-rural county type, 1953–54

Per capita income of county, 1950	Total population [1]	Number of beds		Beds per 1,000 population	
		General hospitals	Nursing homes	General hospitals	Nursing homes [2]
All counties	150, 697, 361	564, 826	171, 106	3. 7	1. 2
Less than $500	4, 526, 178	5, 962	520	1. 3	0. 1
$500–$999	31, 416, 731	78, 496	16, 661	2. 5	. 5
$1,000–$1,499	61, 033, 532	235, 205	78, 216	3. 9	1. 3
$1,500 and over	53, 710, 920	245, 163	75, 709	4. 6	1. 4
Metropolitan and adjacent counties	**109, 272, 372**	**425, 168**	**140, 363**	**3. 9**	**1. 4**
Less than $500	1, 089, 100	1, 266	169	1. 2	. 2
$500–$999	11, 309, 532	23, 936	7, 714	2. 1	. 7
$1,000–$1,499	44, 539, 219	162, 182	58, 662	3. 6	1. 3
$1,500 and over	52, 334, 521	237, 784	73, 818	4. 5	1. 4
Isolated counties	**41, 424, 989**	**139, 658**	**30, 743**	**3. 4**	**. 8**
Less than $500	3, 447, 078	4, 696	351	1. 4	. 1
$500–$999	20, 107, 199	54, 560	8, 947	2. 7	. 4
$1,000–$1,499	16, 494, 313	73, 023	19, 554	4. 4	1. 2
$1,500 and over	1, 376, 399	7, 379	1, 891	5. 4	1. 4

[1] 1950 census.

[2] Bed ratios for national and county-type totals are computed on estimated total number of beds (cf. table 2) rather than on actually reported beds as shown here.

County Characteristics

The availability of beds may be associated with certain measurable characteristics of counties other than their urban-rural character. Per capita income may be one such factor; its influence on the supply of general hospital beds has been demonstrated in earlier studies (*2, 5*). The proportion of the population aged 65 years and over may be influential, in view of generally greater use of both hospital and nursing home facilities by this age group. Another related factor may be the relative availability of medical personnel, including physicians and professional and practical nurses.

Per Capita Income

That the supply of beds in general hospitals and skilled nursing homes in counties tends to increase with per capita income is evident from table 4.

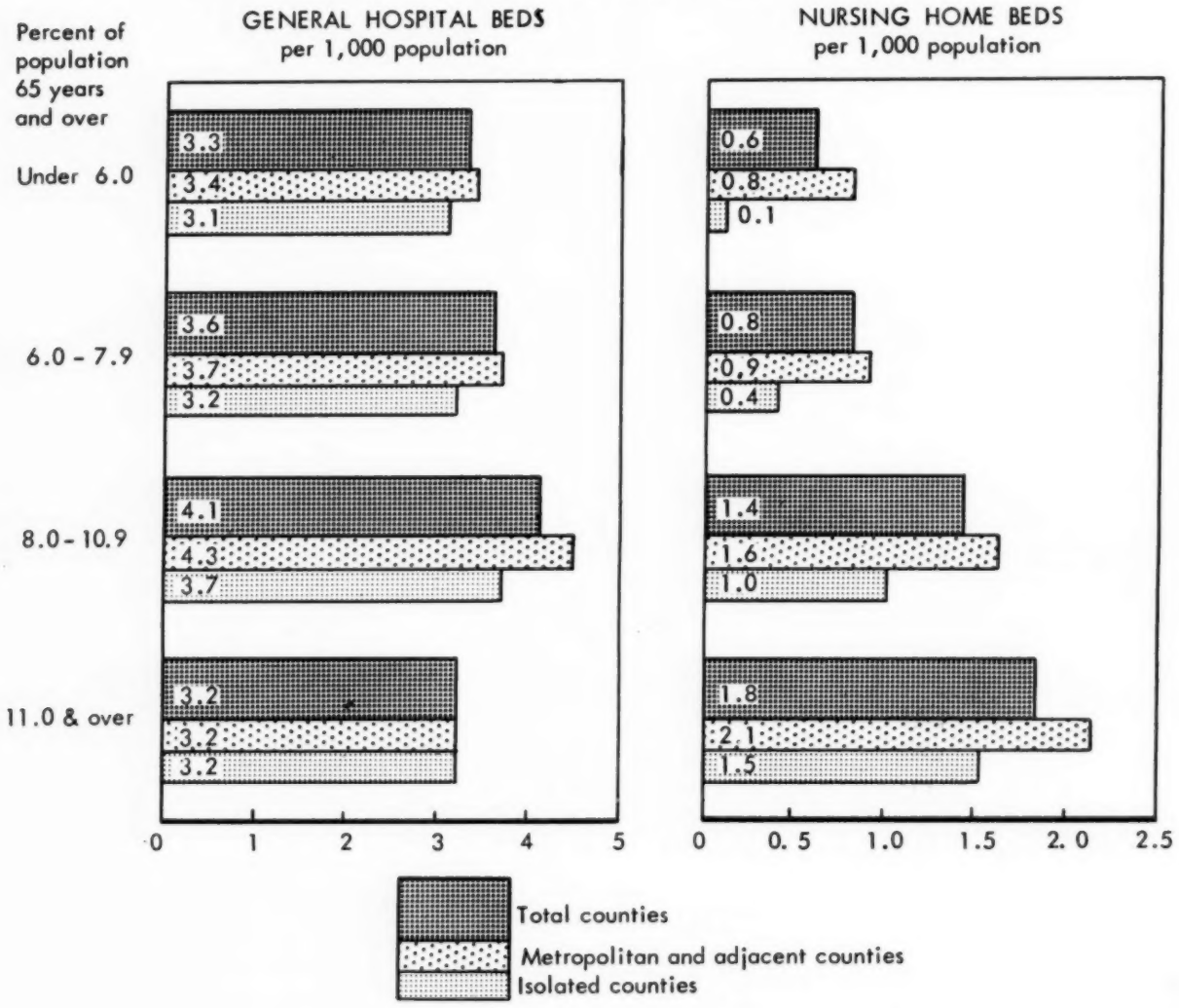
The volume of beds in nursing homes shows proportionately greater increases with increasing income levels than does the volume of beds in general hospitals. However, the individual counties do not adhere closely to the overall tendency which shows nursing home beds increasing with income level. Rather, the pattern represents an average of county experiences which are widely dispersed about the general trend. The increase of general hospital beds with increase in per capita income, on the other hand, is more consistently displayed county by county. (The more consistent association of general hospital beds with per capita income is reflected in a correlation coefficient of .45, compared with a correlation coefficient of .27 for skilled nursing home beds—both significant at the 1-percent confidence level.)

Older Population

The proportion of the county population aged 65 years and over is as significant as per capita income in relation to nursing home beds (correlation coefficient of .28). The supply of general hospital beds, however, shows no relation to the number of older people in the area. As figure 2 indicates, this situation is found in both urban and rural counties.

The association of aged population with the availability of nursing home beds is independ-

Figure 2. Average availability of general hospital and skilled nursing home beds among counties with different proportions of older people, by urban-rural county type.



ent of the influence of income level. The relationship with age is maintained even among areas of similar income. (Removing the effect of income, the partial correlation of nursing home beds with aged population is .26, similar to the simple correlation of .28 noted above.)

Medical Personnel

As figure 3 demonstrates, counties with relatively larger numbers of physicians and professional and practical nurses also have, on an average, more general hospital and nursing home beds. This holds true for the different types of urban and rural counties.

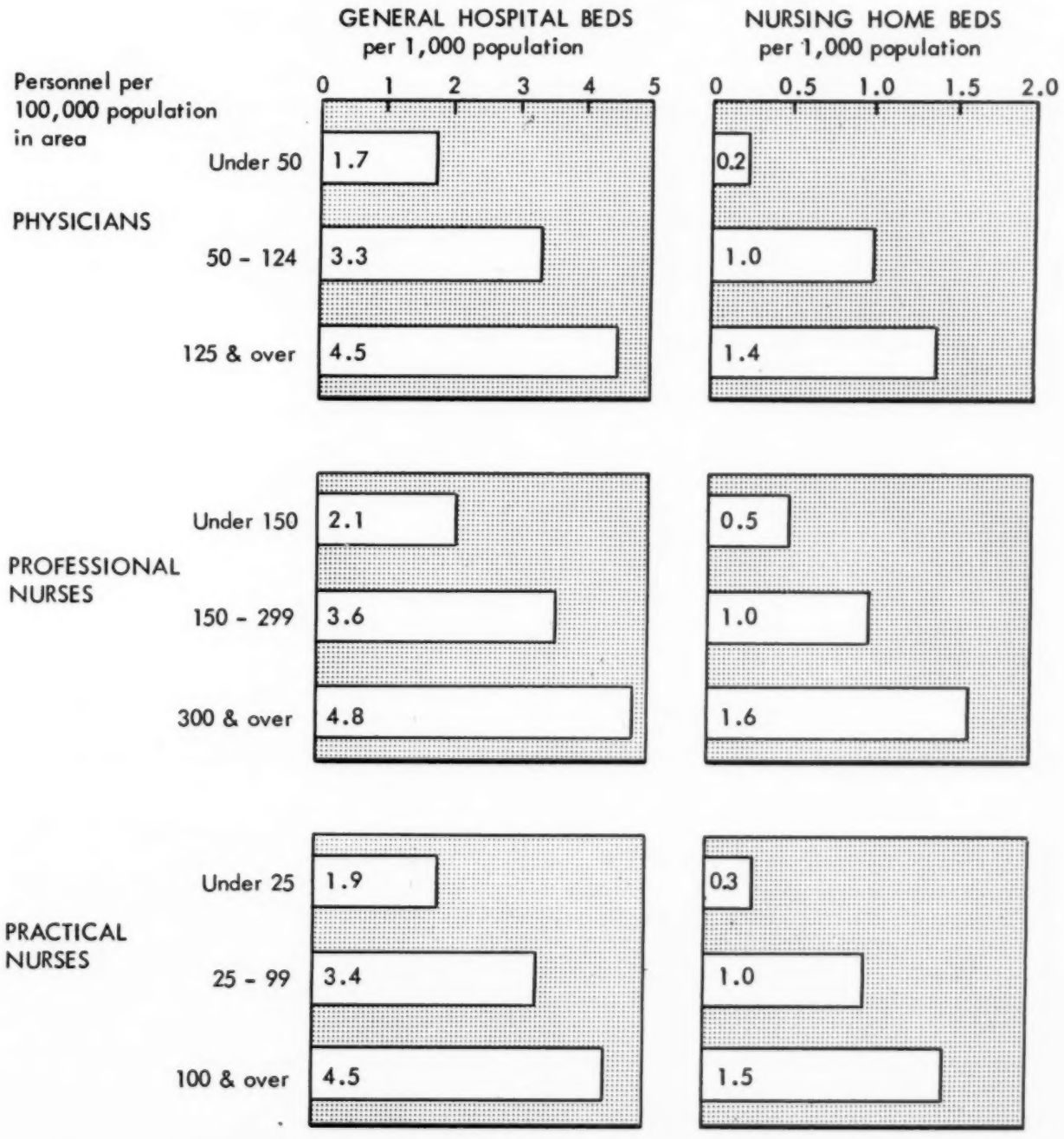
County per capita income probably has an underlying influence here. There is a substantial association between county income levels and the supply of physicians and professional and practical nurses (the three types of medical personnel correlate, respectively, with county per capita income .58, .60, and .29).

To observe the effect of availability of medical personnel alone, with the effect of income removed, the category of professional nurses was examined in detail. This category, as just noted, correlates quite highly with per capita income. It also shows the highest correlation of the three types of medical personnel with the volume of general hospital and nursing home beds.

Ratio	Correlation with county bed-population ratio for—	
	General hospitals	*Skilled nursing homes*
Physician-population	.45	.25
Professional nurse-population	.55	.33
Practical nurse-population	.33	.22

Removing the influence of county per capita income does in fact reduce the extent of correlation between bed levels and the supply of professional nurses. However, a measure of association remains (partial correlations with general hospital and nursing home beds, respectively, of .39 and .21, compared with the

Figure 3. Average availability of general hospital and skilled nursing home beds among counties with different relative availability of medical personnel.



simple correlations of .55 and .33—all statistically significant).

Composite Relationships

Per capita income and complement of professional nurses emerge from the foregoing analysis as rather significant factors associated with the volume of general hospital and nursing home beds in counties. The relative number of older people in an area is an additional important factor in the supply of nursing home beds.

The supply of professional nurses appears as the most effective correlate of availability of general hospital beds among the several factors studied. The nurse factor operates in the same direction as county income level, itself a major correlate, and further effectively incorporates the influence of income level. (Multiple correlation of general hospital beds with both these factors combined yields a coefficient of .57, no improvement over the simple correlation of .55 with supply of professional nurses by itself.)

In the case of nursing home beds, the combined effect of per capita income, proportion of older population, and professional nurse supply is greater than the effect of any one of these alone (multiple correlation of .42, as compared with simple correlations with these factors, respectively, of .27, .28, and .33). Here again, however, the influence of income is adequately reflected in the factor of professional nurse supply. Consequently, the combined effect of aged population and professional nurses yields as high a correlation (.42) with nursing home beds as the correlation with income level included.

Summary

Metropolitan counties, relative to other types of counties, are best supplied with both general hospital and nursing home beds. Isolated rural counties are the least supplied with both types of beds. The intermediate types of counties exhibit opposing patterns between general hospital and nursing home beds: General hospital beds are in rather low supply in those counties adjacent to metropolitan counties and in high supply in isolated semirural counties. Nursing home beds, in contrast, exist in relatively large supply in counties adjacent to metropolitan counties and are in much lower supply in isolated semirural counties.

Little correspondence is found, county by county, between the number of general hospital beds and the number of nursing home beds. Although some average tendency is observed for the volume of nursing home beds to increase as general hospital beds increase, great variability among counties obscures the actual relationship.

The availability of beds is moderately correlated with certain socioeconomic factors. Per capita income and supply of medical personnel form a complex which is significantly related to the availability of general hospital beds. Correlating not as highly, but significantly, with these factors is the supply of nursing home beds. The proportion of county population aged 65 years and over apparently influences the supply of nursing home beds positively but reveals no measurable effect on the volume of general hospital beds.

Beyond the relationships examined in this study, there is much that is yet unexplained in the volume of beds established in different areas. For better understanding we must look to more subtle factors in the medical-sociocultural environment.

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Conference Report

Administration building at the Public Health Service Hospital in Carville, La.

Progress and Potentials in Leprosy Research

A conference on leprosy research, the first sponsored by the Public Health Service's Interbureau Advisory Committee on Leprosy, was held at the Public Health Service Hospital, Carville, La., January 10–11, 1956. In a program planned by the Subcommittee on Leprosy Research, this conference brought together most of the persons in the United States currently studying the disease. Their discussions, which covered bacteriology, animal inoculation, immunology, biochemistry, pathology, metabolism and nutrition, chemotherapy, epidemiology, and clinical observations, are represented here by brief summaries of 25 of the papers.

Mycobacteria in Intracellular Environment

JOHN H. HANKS, Ph.D., *bacteriologist in charge, Leonard Wood Memorial Bacteriology Laboratory, Harvard Medical School, Boston, Mass.*

Metabolic methods of studying mycobacteria, with respect to their behavior during growth, embody two essential features which are quite different from the features of standard bacteriological methods. The first consists of a study of the hydrogen exchange as measured by the quantities of hydrogen liberated when oxygen is excluded from the reaction. Hanks discussed several methods of measuring hydrogen, by means of methylene blue or tetrazolium compounds. In combination with the tetrazolium compounds, the hydrogen produces a variety of colored substances. The second feature consists of study of the oxygen uptake by bacteria in the Warburg apparatus.

Studies by Hanks on the organism of rat leprosy have shown that the fresh suspensions failed to oxidize any one of a large number of test substrates. They have indicated that the substrate is not of particular significance in endogenous metabolism. When the basic substrate is given a yeast supplement, the metabolic effect is enhanced to some degree, but the enhancement is greater when an albumin-yeast complex is provided. Anaerobiasis greatly decreases the metabolic activity of the organism. This capacity of the organism to respire independently of the substrate clearly indicates that in the rat's tissues it is not dependent on cell respiration or intracellular enzyme systems. Although the organism may compete with the cell, it is able to respire or to metabolize independently from the cell.

Hanks discussed the substances present in plasma proteins, particularly with reference to factors that inhibit endogenous metabolic activity. These factors appear to be more effective in relation to the rat leprosy organism than to other mycobacteria. To illustrate, he presented diagrammatic sketches of the metabolism of the murine leprosy organism as affected by various inhibiting factors in plasma proteins. Until metabolic activity of the organism can be shown by metabolic study methods to gain energy in time, there is no point in employing standard bacteriological methods in leprosy, he concluded.

Growth in HeLa Cells of Cultivable Mycobacteria

CHARLES C. SHEPARD, M.D., *Virus and Rickettsia Laboratory, Communicable Disease Center, Public Health Service, Montgomery, Ala.*

Shepard presented illustrations of his work on growth of tubercle bacilli in tissue cultures, using as his baseline H–37Rv human organisms as grown in the HeLa cell. Horse serum in the medium produces much better entry of organisms into the cell than does human serum. However, once bacilli are admitted to the cell, irrespective of the nature of the process, the organisms grow within the cell much better in the presence of human serum. Bacillary suspensions used were from those grown in Tween media, with their very small individual clumps.

Only doubtful growth can be visualized in 24 hours, but substantial growth is evident in 3 days and excellent growth in 5 days. At 7 days, under favorable conditions, growth begins to expand beyond the cell so that from this time onward intracellular growth is complicated by extracellular growth and by possible cell injury. Shepard showed sections and smears confirming the intracellular site of growth and illustrated the cords and perinuclear chains of growing organisms. He indicated an area near the centrosome of the cell as a particularly favorable site for growth.

Shepard concluded with a presentation of data indicating the usefulness of the tissue culture in the measurement of activity of drugs against mycobacteria.

Analysis of Properties of Mycobacteria by Metabolic Study

CLARKE T. GRAY, Ph.D., *biochemist, Leonard Wood Memorial Bacteriology Laboratory, Harvard Medical School, Boston, Mass.*

Saprophytic acid-fast bacteria metabolize succinates, acetates, and both long- and short-

chain fatty acids. Intermediate types still metabolize the fatty acids, but not the succinates and usually not the acetates. Tubercle bacilli metabolize the fatty acids, but rather poorly. Johne's bacillus metabolizes only the short-chain fatty acids. Murine lepra bacilli metabolize none of these substances. This leads to the conclusion, said Gray, that they lie at the extreme pole of the sequence.

Studies of the behavior of various mycobacteria under varying oxygen tensions indicate that, whereas saprophytes may not grow in the absence of oxygen, they are not injured by the condition. However, anaerobic conditions are definitely injurious to lepra bacilli, suggesting a deficient or weak cytochrome system. Oxidative capacities of tubercle bacilli and murine lepra bacilli toward carbon dioxide are roughly equal; neither act on glycerine or glucose.

Tubercle bacilli are active in oxygen metabolism through the pyruvate sequence, but murine lepra bacilli are not. Johne's bacillus has been shown to require a "growth factor," especially for primary isolation. This is doubtful for tubercle bacilli and unknown for lepra bacilli.

Albumin and body fluids have a greater capacity to inhibit the metabolism of murine lepra bacilli than that of tubercle bacilli; for tubercle bacilli, the production of toxic lipids and the inhibition of succinates favor the bacillus vs. cell balance. The metabolic "capacities" of murine lepra bacilli appear to favor their infectiousness for animals.

Inducing Pathogenesis of M. leprae in Animals

WILLIAM H. FELDMAN, D.V.M., *professor of comparative pathology, Mayo Foundation, University of Minnesota Graduate School, Rochester, Minn.*

A method of inoculating animals with *Mycobacterium leprae* obviously would be of value as a means of enlarging understanding of leprosy. Yet, experiences with tuberculosis indicate that duplication of the human disease is not necessarily to be expected. For success, it would appear that the lepra bacillus must survive and reproduce intracellularly. The better known laboratory animals, as well as some others, have proved refractory to infection, but many available species have not been tried.

The intradermal route of inoculation seems not to have been investigated adequately, Feldman suggested, especially from the standpoint of a medium of relatively low average temperature. There are at least two examples of animal mycobacterial diseases in which skin temperature appears to be a determining factor.

Possible procedures for reducing host resistance include whole-body radiation to reduce properdin levels and the use of hormonal substances or agents adversely affecting animal metabolism. The role of lipids in the lepromatous type of granuloma suggests a field for investigation. Adjuvant substances such as silica might be used in the inoculum.

Suggested animals are the anthropoid apes, hamsters, young swine and calves, and wild rodent species. Marsupials have not been studied adequately, although promising results have been obtained with them in related fields. Experiments of long duration should be planned.

The empirical approach to the problem of inoculating animals is necessary as long as nothing definite is known. To date, this approach has not been subjected to the applications of more than a fraction of the imaginative possibilities.

Comprehensive Program for Inoculation of Human Leprosy Into Laboratory Animals

CHAPMAN H. BINFORD, M.D., *chief, Laboratory for Leprosy Investigations, Armed Forces Institute of Pathology, Washington, D. C.*

Binford described the cooperative program of the Armed Forces Institute of Pathology and the Public Health Service Communicable Disease Center laboratories which is designed specifically for experimental inoculation of animals with human leprosy. The animals will be inoculated and kept in the CDC laboratories. The histological study of biopsy and autopsy specimens of the inoculated animals will be done at the Armed Forces Institute of Pathology.

Binford elaborated the numerous details which support the thesis that in man the lepra

bacillus has a natural preference for sites of lower body temperatures, and he expanded upon methods of applying this temperature selection to animal experimentation, using the most superficial inoculations practical and attempting to lower skin temperatures by frequent clipping of the fur of the animals. Mice of a hairless strain will also be used. Since in man the lepra bacillus has a predilection for peripheral nerves, intraneural inoculation will be tried.

For use in this animal inoculation program, human leprosy tissue frozen in solid carbon dioxide has been obtained from untreated patients in the Philippines and shipped by air to Washington. This was made possible by the cooperation of leprologists of the Philippine Government and the Leonard Wood Memorial and pathologists of the United States Air Force and United States Army in the Philippines and in Tokyo.

Possible Approaches to a Study of Antibody Responses in Leprosy

DONALD S. MARTIN, M.D., *chief, Bacteriology Section, Communicable Disease Center, Public Health Service, Chamblee, Ga.*

According to Martin, questions of serology in leprosy cannot be advanced far until bona fide cultures of the organism are available. In submitting a number of suggested procedures, he recommended study of the many variations in a few carefully selected patients. His discussion dealt primarily with possible applications in leprosy of the more recently developed serologic techniques, such as the Middlebrook-Dubos hemagglutination technique, which measures the specific anticarbohydrate titers. As in blastomycosis, there could be a relation in leprosy between protein antibodies and prognosis. Studies to separate the different protein and carbohydrate antigens and their antibodies could be approached, albeit only indirectly until cultures are available.

Methods of study potentially available include using precipitin bands in gels, tannic-acid-coated cells, and electrophoretic potentials of the reacting areas.

Possible Uses of the Properdin System in Studying Immunity and Bacteriology

JACK W. MILLAR, *Lt. Comdr., MC., USN, commanding officer, Naval Medical Research Unit No. 1, University of California, Berkeley, Calif.*

Approaches to the study of properdins in leprosy, both as they occur in the patient and as they might be activated or inactivated to alter infectivity of leprosy for animals, were discussed by Millar.

Briefly, properdin is a normal serum constituent, differing from antibody—a euglobulin activated by complement and magnesium. It kills or inactivates certain bacteria, lyses red cells, and combines chemically and reversibly with a yeast-carbohydrate complex (zymosan), from which compound it can be isolated. Properdin activity can be blocked temporarily in vivo by certain compounds, many of which occur in bacterial cell walls. Properdin is lowered by radiation.

Separation of Leprosy Organisms From Tissues

HOWARD J. HENDERSON, *research associate, Henry Phipps Institute, Philadelphia, Pa.*

Henderson proposes to separate the lepra protein antigens from suspensions of tissues rich in leprosy organisms, by homogenizing the tissue, overlaying the suspension with oil, and collecting the acid-fast material, by centrifuge, at the oil-water interface. Preliminary work was done by Henderson nearly two decades ago. He believes that, granting an adequate supply of material, this method will yield sufficiently concentrated bacilli to enable chemical studies of their protein moiety, lipoprotein moieties, and others. Various techniques have become available since his earlier studies.

Studies in Serology

SISTER HILARY ROSS, *biochemist, Public Health Service Hospital, Carville, La.*

Serologic studies in leprosy have had different objectives. Complement fixation tests have

been used in trying to identify the cultivated organism with that of the disease. Complement fixation tests, flocculation tests, and agglutination tests have been used for diagnostic or prognostic purposes.

The various serologic tests performed at Carville in the past 30 years were reviewed by Sister Hilary Ross. She described in detail the flocculation test devised by Olmos Castro and discussed its possible value as a routine laboratory method in the detection of overlooked cases of lepromatous leprosy in endemic areas. Also of possible value in leprosy is Middlebrook's hemagglutination test. A proposed study designed to detect specific antibodies in leprosy serum was outlined.

Induction of Reactivity to Lepromin by BCG Vaccine

JAMES A. DOULL, M.D., *medical director, Leonard Wood Memorial, Washington, D. C.*

In a carefully controlled study in the Philippines, Guinto, Doull, and Mabalay found that in 71.2 percent of previously negative children, the lepromin (Mitsuda) reaction had become positive 90 days after BCG vaccination. In control groups given saline or diphtheria toxoid, the proportion becoming lepromin positive was 27.1 percent, a finding that is attributed to natural (unknown) causes or the lepromin test itself, or to both.

By the device of leaving a sample of the originally selected children untested at the outset and unvaccinated, it was possible to compare the final lepromin status of three comparable groups: (1) children given BCG and an initial lepromin test, (2) children given saline or toxoid and an initial lepromin test, and (3) the basic controls. From comparisons of these groups, it was estimated that the proportion of all children who had become lepromin positive because of BCG was only 33.4 percent, because of the lepromin test, 7.2 percent, and because of natural causes, 11.5 percent.

Natural acquirement of reactivity is of great interest. It is too frequent to be accounted for by exposure to leprosy. It can hardly be caused by exposure to tuberculosis because only 2.3 percent of these children reacted to tuberculin (5 T.U. of PPD–S) at the outset as compared to 23.2 percent that showed reactivity of the Mitsuda type.

The Marianum Antigen in Leprosy

ROLLA R. WOLCOTT, M.D., *clinical director, Public Health Service Hospital, Carville, La.*

Wolcott presented three of a number of patients who were receiving monthly intradermal injections of a killed culture of a mycobacterium (called *Mycobacterium marianum*) isolated from a leprous nodule by Sister Marie Suzanne of Lyons, France. In all these patients, prolonged sulfone treatment had failed. Some local reactions to the antigen had occurred, indicating some type of activity on the part of the vaccine, but it was too early to say whether the vaccine was beneficial. No biopsies of the reactive lesions had as yet been made. The antigen was being used as a supplement to sulfone or other therapy.

Protein Patterns in Leprosy

RUDOLPH J. MUELLING, JR., M.D., *associate pathologist, Charity Hospital, New Orleans, La.*

Chemical fractionation and paper electrophoresis studies by Muelling of serum protein in patients with leprosy gave the following results.

Active: 98 patients. The total globulin was usually elevated. The total protein level depended on the level of the serum albumin. The most common globulin aberration was a single clear elevation of the gamma globulin. A two-fraction elevation of the beta and gamma fractions came next, followed by a generalized increase in globulin with a predominant rise in gamma globulin. The lipoprotein was not remarkable. Fifty-five of the patients showed peaking elevation of the mucopolysaccharide. This fraction seems to be related to activity of the disease.

Amyloid: 15 patients. The total protein was elevated or not, depending on the level of albumin. As the albumin disappeared, there was an increasing curve reversal. There was more

single-fraction elevation than double-fraction; if there was a general increase, it was overwhelming.

Tuberculoid: 17 patients. The albumin was usually normal. The total protein varied between 7.3 and 10.4 grams percent. The beta globulin was usually increased over gamma globulin. Alpha elevation was rare. The mucopolysaccharide was usually not elevated (11 patients out of 17); when increased, the increase was usually the type produced by a general infection. The lipoprotein was usually increased, probably because of the beta globulin increase.

Inactive: 30 patients. Two out of the 30 had elevated mucopolysaccharides.

Muelling offered suggestions for further investigations, particularly of the idea that the mucopolysaccharide levels are related to activity of the disease. Dr. Catherine Goetz and Sister Hilary Ross participated in the studies.

Histopathology and Leprosy

GEORGE L. FITE, M.D., *Laboratory of Pathology and Histology, National Institute of Arthritis and Metabolic Diseases, Public Health Service, Bethesda, Md.*

Fite posed the question: How does the accumulated knowledge of anatomic leprosy suggest or indicate lines for further inquiry? He declared that any consideration of advanced leprosy anatomically is ridiculous, as compared with the need for knowledge of the early phases. Classifications of leprosy are of themselves worthless. They are of value only in indicating where to look for the factors that determine whether a patient, including the "no leprosy at all type," has this or that type of leprosy.

Although studies of terminal nerves and nerve endings in early leprosy might yield a clue to a finite mechanism, it would be the mechanism that was important, not the nerve-ending involvement of itself. Fite discussed the realms in which the determinant factors might lie, indicating that none of them involved a primary histological study.

The epidemiologist has learned that the study of the epidemiology of the lepromatous disease alone is almost valueless. The serologist might profit by the lesson: The place to search for serum antibodies may not be the person with the disease, but the exposed individual without the disease.

Amyloidosis in Leprosy: Observations in Pathology

LAWRENCE L. SWAN, M.D., *Lafayette Medical Laboratory, Lafayette, La. (formerly, chief of pathology, Public Health Service Hospitals, New Orleans, and Carville, La.)*

In 50 consecutive autopsied cases of leprosy, amyloid disease was the definite cause of death in nearly 40 percent, and was present in more than 46 percent. Figures available indicate that amyloidosis is not as important in leprosy in other countries, but the subject is not well studied. The disease, which is associated with abnormalities in the serum globulin, is still difficult to identify during life.

At Carville, amyloidosis has occurred in cases without such complications as tuberculosis, throat complication, syphilis, or chronic ulcerations, showing that leprosy of itself is factorial.

Chemotherapy of Murine Leprosy

Y. T. CHANG, M. D., *Leonard Wood Memorial fellow in pharmacology, National Institute of Arthritis and Metabolic Diseases, Public Health Service.*

Chang presented a review of the work on chemotherapy in murine leprosy. Mice are used as the experimental animals, and measurement of intraperitoneal lesions following intraperitoneal injections is used as the criterion. Test experiments require 3 months. This test, according to Chang, is as sensitive as similar tests for in vivo activity against tuberculosis.

Thirteen compounds have been tested: streptomycin, chlortetracycline, oxytetracycline, chloramphenicol, erythromycin, nicotinamide, pyrazinamide, para-aminosalicylic acid, amithiozone, isoniazid, B–283, diphenylthioureas, and sulfones. Only five of these, streptomycin, nicotinamide, pyrazinamide, isoniazid, and diaminodiphenyl-sulfone, were found active. Recently, cycloserine has also proved effective. Comparison of the various effectivities indicates

that murine leprosy gives a spectrum closer to human leprosy than does murine tuberculosis.

Some variation in duration of experiments and drug withdrawals have been studied in relation to drug effectivities.

Epidemiology of Leprosy in Louisiana

L. F. BADGER, M.D., *chief, Leprosy Control Unit, Communicable Disease Center, Public Health Service, Atlanta, Ga.*

On the basis of an epidemiological study of leprosy, especially as seen in Louisiana, Badger stressed the following points:

1. The ideas that the disease is feebly contagious and that prolonged exposure is necessary are not supportable. The figures show that infections in children have been overemphasized; a good many occur after exposure in adult life. The sex incidence seems of relatively little or no significance.

2. The source of infection is more frequently outside the family than within.

3. Early recognition and early treatment are essential to control. Extensive case finding, in contrast to casual discovery of new cases, must be undertaken.

4. There is no basis for assuming that the disease could not appear and spread through other parts of the United States.

Leprosy Control in Louisiana

WILLIAM H. MEYER, M.D., *leprologist, Louisiana State Department of Health, New Orleans, La.*

Leprosy may have been introduced into Louisiana by slaves brought into the colony between 1719 and 1732. Or it may have been introduced from the earlier Spanish colonies in Mexico and elsewhere, as it is known that leprosy existed in those colonies in early days.

The first recorded control effort was the establishment by the Spanish governor Ulloa of an isolation area for persons with leprosy at Bolize in 1766. Historical records show also that from 1785 to 1807 there was a leprosy hospital near New Orleans, but from 1807 to 1880 nothing seems to have been done. In 1894 the State established a hospital for leprosy patients and in 1921, gave it to the Federal Government.

Current control efforts include visits to the patient's home by the physician to obtain information concerning possible sources and new cases of the disease.

There has been a steady decrease in admissions from Louisiana to the leprosy hospital at Carville. An estimated one-third or more of the AWOL cases from Carville reside within the State.

The Risk of Contracting Leprosy in the Household

FRED C. KLUTH, M.D., *Leonard Wood Memorial associate epidemiologist, Texas State Department of Health, Corpus Christi-Nueces County Health Unit, Corpus Christi, Tex.*

Among 456 household contacts of lepromatous leprosy patients in Texas, 12 new cases of leprosy (2.7 percent) were discovered. Nine others were suspected but unproved; some of these were in older individuals and were possibly inactive. In 78 nonhousehold contacts, 2 cases were discovered. In 112 contacts with cases of tuberculoid leprosy, leprosy was suspected in 1 and definite in 1.

In agreement with Meyer, Kluth emphasized the need for quiet and unheralded operation of contact investigation, with minimization of the "official" character of home visits, even to the point of mild deception of the patient's neighbors.

The number of new cases of leprosy in Texas each year remains about stationary. In 1955, there were 24, all from the usual foci. The average age of onset is surprisingly high, over 30 years.

Clinical Evaluation Studies of Drugs

JAMES A. DOULL, M.D., *medical director, Leonard Wood Memorial, Washington, D. C.*

Clinical evaluation studies of drugs in leprosy have been conducted by the Leonard Wood Memorial during the past 4 years in widely separated institutions in Japan, South Africa, and the Philippines. Results from the different institutions are similar.

The first series, with 852 patients, proved too complicated to be completely satisfactory. Five drugs or drug combinations and one placebo were used. Diasone, diaminodiphenyl-sulfone, and streptomycin proved equally effective. There was no advantage in the combined drugs and no effective bacteriological improvement.

A second series of 499 patients gave equal results with diasone, isoniazid plus diasone, dihidrostreptomycin, isoniazid and streptohydrazid.

In a third series now in progress, BCG vaccination in combination with drug treatment is being studied.

Additional pilot studies in the Philippines are designed to examine isoniazid, thiosemicarbazone, pyrazinamide, cycloserine, and combinations of these. Thus far, none of the hepatitis and convulsive complications have been met.

The first series, according to Doull, provided the first statistical evidence of the value of the sulfones in treating leprosy. Such evidence is absent in many of the reports of drug treatments.

Seromycin Trials in Leprosy

FRANK E. LUNDIN, Jr., M.D., *Public Health Service Hospital, Carville, La.*

Lundin reported the results of experimental treatment of 10 patients with seromycin. The dosage was 250 mg. every 12 hours. Treatment in two patients was discontinued because of complications. Five patients received sulfones in addition to seromycin. No bacteriological improvement has been recorded. Although there was probably some improvement, it was no greater than might be recorded from sulfone treatment alone.

Hemoglobin Types in Leprosy

HORATIO C. WOOD IV, M.D., *Public Health Service Hospital, Carville, La.*

In studies at Carville on the distributions of various genetically determined types of hemoglobin, no differences were observed between the leprosy patients and normal populations.

Orthopedic Procedures in Leprosy

DANIEL C. RIORDAN, M.D., *division of orthopedics, Tulane University School of Medicine, New Orleans, La.*

Orthopedic procedures used for the prevention and alleviation of deformities resulting from leprosy were described by Riordan. He mentioned in particular ulnar nerve transplantations from the superficial site to a deeper site, in order to prevent trauma to the nerve, and opening of the nerve sheath in older cases, which often gives immediate relief of nerve pain.

Other reconstructive procedures used are:

1. Shoe corrections, drop-foot braces, and splinting to prevent hand deformities.
2. Toe and metatarsal amputations, removal of ulcers plus underlying bones, joint fusions of hand joints plus bone shortenings, fixations in half-grasp positions in severe cases, and tendon transfers.

Limitations of Sulfone Therapy

ROLLA R. WOLCOTT, M.D., *clinical director, Public Health Service Hospital, Carville, La.*

Reviewing the story of the introduction and spread of sulfone treatment, Wolcott emphasized that the sulfones have their limitations. He concurred in Doull's remark that statistical studies clearly indicate the need for a more effective drug. According to a "probability of arrest" chart, a patient with lepromatous leprosy has a 40 percent chance of arrest of the disease after 8 years of steady sulfone treatment. This is not a good probability for an 8-year course of treatment. However, many other benefits accrue from the sulfones, especially in prevention of complications. Tracheotomies, once steadily performed, are not required; there is far less need for minor amputations, and almost certainly life expectancy is improved.

Studies in Clinical Biochemistry

FRANK E. LUNDIN, JR., M.D., *Public Health Service Hospital, Carville, La.*

Lundin reported briefly on clinico-pathological examinations of electrolytes in leprosy, BSP tests, and cold precipitable lipoproteins. In determinations of magnesium, calcium, phosphorus, and potassium, many serums gave results below the control range. Sodium and chloride showed a few serums above the range for normals. In six of the BSP tests, there was abnormal positive retention for which there was no explanation. Five of 144 patients showed protein precipitates in serums refrigerated for 24 hours. The precipitates redissolved on warming and were shown by electrophoresis studies to be lipoproteins.

Treatment of Ocular Complications

STEPHEN J. HERBERT, M.D., *Public Health Service Hospital, Carville, La.*

Eye complications in leprosy, in particular improvements in treatments of oculomotor nerve residuals and the problems of treatment of keratitis, lid reconstructions, and the like, were reviewed by Herbert. Misconception and mistreatment of the secondary glaucomas have followed acute attacks of iridocyclitis in leprosy in the past.

Grants-in-Aid for Training in Air Pollution Control

Grants-in-aid for graduate training in air pollution prevention and abatement are now available from the Public Health Service.

Designed to increase the number, competence, and knowledge of professional personnel engaged in community air pollution control work, the grants-in-aid will be awarded to three groups: State and local air pollution control agencies or other public agencies for training their personnel, educational institutions for assistance in developing and supporting new courses, and individuals for specialized training in air pollution.

In awarding the grants, the Public Health Service will consider such factors as severity of the air pollution problem, appropriateness of the proposed course, and qualifications of the prospective trainee. Grants to public agencies and individuals will cover tuition and fees, travel expenses, and subsistence allowances or stipends. Those to educational institutions may be used to pay all necessary expenses connected with a course, including salaries of instructors. Grants will be limited to 12-month periods, but in most instances they may be renewed for additional periods.

Those interested in training during the 1956–57 academic year should apply as soon as possible. For each academic year thereafter, applications should be submitted by April 1 of the preceding academic year. However, grants will be awarded as vacancies occur, and applications may be submitted at any time.

Additional information and application forms may be obtained from the regional offices of the Public Health Service or from the Chief, Division of General Health Services, Bureau of State Services, Public Health Service, Washington 25, D. C.

Public Health Begins in the Family

By HALBERT L. DUNN, M.D., and MORT GILBERT

THE FAMILY, as the most important institution in society (*1*), is intensively studied by sociologists and anthropologists. It is seldom studied by public health agencies, and it is almost entirely outside the current framework of vital and health statistics.

Births, deaths, diseases, marriages, and divorces are generally reported as events occurring to individuals. Our routine statistics tell us next to nothing about the family setting or family situation of these individuals or about the role of the family in health and disease. Although information of this type is admittedly difficult and perhaps impossible to derive from routine records, it is quite feasible to collect routine data on the "universe" of American families. The factual background would provide a base for specialized sample studies.

In this paper we will suggest, on the basis of existing statistical mechanisms, some of the ways in which public health agencies might proceed to collect usable data on families as well as on individuals. This of course raises a larger question, which we will attempt to explore first: What does the family have to do with public health?

Dr. Dunn is chief of the National Office of Vital Statistics, Public Health Service, and Mr. Gilbert is publications officer. Dr. Dunn presented a slightly longer version of their paper at the meeting of the Southern Branch of the American Public Health Association at Tulsa, Okla., April 4–6, 1956. *Other reports on the family-centered approach to public health are presented on pp. 1011–1031.*

With some 40 million families in this country—the number depends on how family is defined—most of us have firsthand knowledge of only a few. Nearly everybody defines the family differently and holds strong, individual opinions on its character. High divorce rates, dispersion and mobility of families, changes in moral codes and in occupation patterns, and, until the 1940's, falling birth rates had convinced many that the family as an institution was crumbling. The consensus of modern studies is that the family is going through a profound transition but that it shows no signs of leaving the social scene.

Over the Past Century

To gain perspective on the structure and functions of today's family, it may be helpful to compare it with the American family of a century ago. Ignoring cultural variations and concentrating on the typical American family, we have surveyed the extensive literature of family sociology, starting with Ogburn's classic analysis, "The Family and Its Functions" (*2*), and including many of the more recent works. Although interpretations and emphases are controversial because nearly all aspects of the family need more intensive research, most students of the family appear to agree that the following changes and effects between 1850 and 1950 have been significant.

The family has shrunk in size.

Today's typical family has fewer children and is limited to two generations, parents and minor children. What sociologists call the "extended family"—several generations living near together and bound by close ties—has

given way to the "nuclear" family of parents and minor children, who live apart from other kin and keep in touch largely through Christmas cards and occasional visits. As children mature, they leave the parental home to form separate nuclear families of their own, in a continual fragmenting process.

Today's family is mobile.

In this moving van era, a high proportion of families pick up and move to a new community, away from former friends and relatives, to take advantage of new job opportunities.

Dependent aged parents are now less likely to be supported by their grown children.

Rejection or isolation of the aged, linked in part to the modern family structure and functions (*3*), has contributed to a major health problem. Many of the ills of the aged (for example, much of the so-called senile dementia) flow not only from organic aging but also from roles of social isolation dictated by family, cultural, and economic rejection (*4a*). From a public health viewpoint, it is important to investigate the ways in which the changing family, among other forces in the social environment, has affected the aged.

The production of most goods and services has passed from the home to the factory and to service industries.

In 1949 for the first time the number of wives employed outside the home exceeded the number of employed single women. Women in the home perform fewer economic functions: They no longer preserve great quantities of food, make the family's clothing, or cultivate large gardens (*5*). The typical family of a century ago was rural and a major productive unit. Wives were valued in proportion to their economic contribution, which in large part determined the family's status. Children were valued as producers. The change in the family as an economic team, today less frequently operating a farm or family business, is widely believed to be a contributing factor to its shrinkage in size and its relative instability. For the most part, only outside wage earners now make a direct contribution to the family's income although wives and children still may perform economic services at home.

The family's formal control over the decisions of its members is much less than in past years.

The patriarchal figure, except in a few subcultures, has receded into myth; nowadays, grown children tend independently to choose careers, mates, and neighborhoods. Much of the family's former recreational, protective, and related functions have been transferred to community agencies, or they are purchased as services. Not all families and not all members of the family accept the changes equally or necessarily integrate them into their attitudes and emotions. Emotional conflict or deprivation often accompanies such a transformation, with implications for individual and public health.

The divorce rate, though down somewhat from its prewar peak, is relatively high as compared with levels of 1850 or 1900.

The future divorce rate will be affected by probable continuation of past changes in the family which have tended to weaken its stability (*6a*). Most of the evidence suggests that divorce is relatively more frequent in families with fewer children although we do not know to what extent children are a deterrent to divorce (*7*). (The past and present extent of desertions—the "poor man's divorce"—is unknown.) With the decline of the extended family and the anonymity of the urban family, particularly in a new community, there is less pressure by relatives and friends to keep the family together. The reduction of the family's economic functions diminishes the material dependence of the marriage partners on each other.

The Irreducible Functions

In view of the major changes and loss of functions, does the family still serve purposes of sufficient importance to assure its survival? The available data, fragmentary as they are, leave no doubt as to the affirmative answer. Marriage is more popular in the United States than ever: People now marry at a considerably younger age than, for example, in 1890; a much larger proportion of men and women are married today than two generations ago, and, though divorce rates are high, the remarriage rate is also high.

For the family to lose many of its traditional functions but still to become personally important to more people than ever before would

seem to present a paradox. Parsons and Bales (*8a*) in a recent study of family structure in the light of group interaction theory, resolve it this way:

"The family has become *a more specialized agency than before*, probably more specialized than it has been in any previously known society. This represents a decline of *certain* features which traditionally have been associated with families; but whether it represents a 'decline of the family' in a more general sense is another matter; we think not. . . . The family is not in any general sense less important, because the society is dependent *more* exclusively on it for the performance of *certain* of its vital functions."

These remaining vital functions include the rearing of children and the stabilization of the adult personality. Each is basic and irreducible, and in our culture it is difficult to imagine how they could be transferred to any other agency. Since the family is indispensable for bringing up the child and providing an emotional setting for most adult personalities, its optimum performance could avert many of the strains and maladjustments that now require pediatric, general medical, and psychiatric service.

The Rearing of Children

The newborn infant is without language, habits, customs, moral values, skills, or differentiated patterns of emotional expectation and response (*9, 10*). It is the family's function, particularly during infancy and the 6 early "golden years" of personality development, to transform the child into a social creature who is at home in the culture, and who carries and acts out the culture patterns without undue strain. The family has been variously called the cradle of the personality, the nursery of human nature, the porous buffer that lets the child meet experience as he can assimilate it, and that protects him from parts of the environment damaging to him if encountered too soon (*4b*).

It is in the family that the child acquires the basic patterns of living—everything from table manners to ethical values. He learns to look for certain types of emotional response from others, to strive for various types of approved experience, to avoid experience that brings him pain and disapproval. Interacting with his family, learning how to win acceptance and avoid rejection in this small world, he forms behavior patterns, attitudes, and even deep-seated emotional reactions that will profoundly affect his character and personality throughout life.

The family experience begins to provide the child with a usable set of responses, attitudes, and habits that will later enable him to function as an independent adult in society. Without this foundation, human behavior would be totally unpredictable, and even an uncomplicated social structure would be unworkable (*11a*). But the family, in its infinite variety, does more than this. No child-rearing family is society in miniature, but a unique group that is easy to differentiate from any other group.

Children in a family setting acquire not only the generalized patterns of the culture but also a unique interpretation of the parents' subculture. Although all children of the same generation in a society develop much the same kind of human nature, each child is somewhat different from the products of other families. Thus the role of the family is not only to nurture a new generation that fits into the society but also to provide the great variety of personalities that society needs (*8b*).

Infants and small children in order to thrive apparently need personal, adult response over and above the satisfaction of hunger and other physiological needs. The high death rate that prevailed in even the most sanitary foundling institutions and the host of studies demonstrating damage in institutionalized children are often cited as evidence of the child's need for personal attention (*12*). This is a principal reason that foundlings and young orphans are placed in foster families as quickly as possible: Even a poor family generally does better by the child than a scientific regimen without personal interest.

But, as the psychologist John Dollard has remarked, "domestication" of the child "is without exception a process attended by conflict and strain" (*13*). Though the family is the best source of healthy, well-adjusted children, it is also the source of cases that crowd outpatient and child guidance clinics. This is not

the place to catalog child ailments that have their principal genesis in family maladjustments. A vast literature of psychopathology deals with the pathetic results of parental overprotection or rejection; of prolonged mother-child separation; of hostile, overpunishing, or hypercritical parents; of abnormal sibling rivalry; of homes with continuous tension and discord; and sometimes of homes broken by divorce, desertion, or death. Public health is interested in the family if for no other reason than to investigate the etiology and prevention of a wide range of childhood ills.

Though the American family today is most likely to be small and urban, the dominant ideal still clings to rural ways and large kinship. The American family concept has never adjusted to the facts of city life. Many people have not yet learned to live in the modern family, and this lag has contributed to family ill health. In the small, isolated family unit, every relationship is intensified and more continuous (*14*). A child slighted by his mother cannot seek or expect comfort from his aunt if the aunt lives in another city. Bossard makes this point (*15*):

"It is the consensus that many Americans suffer from a sense of insecurity, and there can be little doubt that this is in part a heritage of the immediate family form. The very size of the family unit is important to the child in this respect for the same reason that the size of the ledge from which we view the precipice below affects our sense of security. The American child who lives and matures in a father-mother-child family unit stands on a very narrow family platform, even if it is in no way imperiled. To this is added the constant danger for the child that the few persons he must rely on may falter or fail."

Despite vast clinical experience with psychosomatic illness, despite millions of hours devoted to the recall of childhood traumas, there still is no agreement on the role of childhood experience in the development of health or sickness in adults. Many cases of the so-called "maladaptive reactions" of adults—the chronic fatigue or neurasthenic syndromes, the organ neuroses such as peptic ulcer and colitis, the disabling hysterias, the anxiety disorders, and the other psychophysiological ills—have been traced (to the satisfaction of most psychiatrists and clinical psychologists) to inappropriate patterns learned too rigidly in childhood (*16–18*). Wartime evidence indicated that even the strong personality has a breaking point under sufficient traumatic stress; psychological disorder in adults does not necessarily stem from childhood maladjustment (*19*). Though the evidence is mixed, the family of childhood undoubtedly affects adaptations to stress in adult life. Whether we habitually react to stress or frustration by withdrawal, aggression, escape in fantasy or functional illness is often a reflection or continuation of fundamental patterns acquired in early life.

The Adult Personality

Emotional security in our culture is based mainly on assurances of affection and intimate companionship with other individuals. Human nature has a basic need for favorable emotional response from others (*11b*). No one outgrows it, and most suffer unhappiness and psychic, even physical, ills without it. This brings us to the other major function of the family: the stabilization of the adult personality.

The individual in an urbanized culture is often isolated and largely anonymous. He may be separated from kin and from most of his old, intimate friends. He makes new friends but in relatively formal relationships. Winch refers to the prevalent feeling of loneliness, to "the separation anxiety" that is apparently characteristic of today's society (*20*). For many individuals, the family has survived as the only remaining primary group, which Murphy defines as "the face-to-face world, the world of tenderness and immediacy, the world of security" (*4c*). Except for the family, our lives are now spent mostly in secondary groups—with associates on the job, in trade union or professional meetings, in fraternal or political organizations. We use these for many purposes, but they cannot meet our deep-seated need for love and emotional security. In this respect the family has become much more significant, and this is perhaps an important reason for its persistent strength.

Shurtleff has pointed to associations between marital status and mortality (*21, 22*). Taking

the 1949–51 death rates of married men as equal to the index 100, Shurtleff found that the age-adjusted rate for single men was 163. For widowers it was 185, and for divorced men 207—more than twice as high as for married men. For women, the comparable index figures were: married women, 100; single women, 124; widows, 155; and divorcees, 155.

The figures themselves do not indicate whether marriage keeps people well or whether people who are well tend to marry and stay married. But various students of divorce, particularly the late sociologist Willard Waller, have likened the traumatic effects of separation to those of bereavement. They speak of the "terrific ego shock," the often "shattering" and "calamitous" effect of divorce on the personality, and point to the frequency of depression and occasionally suicide in the series of divorces that have been investigated (*6b*). Some recent studies suggest that the long-term personal disorganization that often followed divorce in the past is now on the decrease, perhaps because divorce has become socially more acceptable. But divorce, desertion, and bereavement are still major social forces with health aspects that deserve study and perhaps action programs.

The nature of marriage in our culture warrants study of its implications for public health. When the nuclear family is the only continuous intimate association, the partners expect more of each other in emotional response. This is one example of potential stress in an age of transition, characterized according to Kirkpatrick, "by confusion as to the family tradition." He continues: "Tangled ideologies produce family dramas for which the script and roles are not clearly defined. It is no wonder that family tragedies are enacted and that family members suffer confusion, anxiety, and unhappiness" (*23a*). Research studies of marital stress are inconclusive, but they indicate that a substantial proportion of husbands and wives are tense and unhappy in their marriage. Weiss and English, whose monumental survey of psychosomatic medicine includes a wide range of family-related illness, noted that "the advice to marry and have children has been a frequent prescription for certain ailments. But, paradoxical though it may seem, many illnesses arise from the marriage situation, and this fact has not been so clearly appreciated" (*24*).

In two recent population studies in New York City and a rural part of New York State, and in a study of routine admissions to the surgical service of Cincinnati General Hospital, about half of the people examined in each sample showed moderate to severe neurosis (*25*). Many outpatient clinics and private physicians report that from half to three-quarters of their patients have symptoms primarily nonorganic in origin or have organic pathology which is aggravated by emotional disorder (*26*, *27*).

These studies are cited not to suggest that any known proportion of this well of human misery originates in the family spring but rather to emphasize the need to explore the major human interrelationships that may bear on public health. One of these, though certainly not the only one, is the family situation. As Kirkpatrick says, "The family is the setting for the most intense emotional experiences which the individual has in the course of a lifetime. Birth, puberty, marriage, and death are family experiences. The family is the source of serene security, of anguished insecurity, of love and hate, of pride and shame, of ecstasy and anguish" (*23b*). It is small wonder that the family dramas and crises have a profound effect on the course of health and disease.

Illness and the Family Unit

Fifty years ago the family was the center of medical practice, as suggested in the old, revealing term, family practitioner. Before the era of specialization, the family doctor had a more intimate knowledge of all the family members, of their incomes and ambitions, of the subtle ways in which each reacted to the other. In treating each of his families, he could call on a store of firsthand social, economic, and cultural data, mostly unrecorded on the medical history, and apply this knowledge both to diagnosis and therapy. With the advance of medical science, the family doctor gave way to the specialist who rarely or never saw the patient in a family setting (*28*). Public health was devoted to preventing disease in the community at large, particularly through sanitary control of water, milk, and insects. In recent years, general

medical practice has recovered much of its former prestige, and public health has broadened its interest to include the chronic diseases and their long-term effects on individuals.

But, despite progress, the family often remains in a medical vacuum, largely outside the scope of private medicine and nearly neglected by public health. We say "nearly" because one public health practitioner, the public health nurse, has always focused her attention on the family unit. It has been obvious to her, as to the family caseworker in social service agencies, that health or illness or recovery occurs in a family context.

The public health nurse always has taken stock of the unique family situation, of the family's income and education. Her methods have been mostly rule of thumb, based on the impressionistic data of her own experience. Lack of reliable baseline data on the family as a unit in health and disease has not prevented her from doing an effective job, just as the lack of mortality and morbidity data did not prevent effective work by the physician and the health officer 50 years ago.

But if the needed family data were available, the nurse and every other member of the health professions would learn to use the material, and come to rely on it as much as on our highly developed mortality data. None of us works in the dark by choice. Public health workers along with sociologists, demographers, family service workers, family counselors, child psychologists, psychiatric specialists, and business and market analysts would profit from real knowledge of the "universe" of American families: the norms and the ranges, the averages and the anomalies, and the interrelation of disease with varying families and family situations. Eventually public health, drawing on both the science of medicine and the methods of family casework, must develop an epidemiology of family disorders and diseases. Classical epidemiology knows how to deal with the spread of infectious disease in families, but for lack of technique and data it shies away from explaining why several members of a family develop the same gastrointestinal dysfunction or similar neurotic cardiac complaints. The wide spectrum of public health includes not only tuberculosis, poliomyelitis, and other infectious diseases that are routinely studied and attacked in the family context but also many noninfectious ailments such as obesity, alcoholism, asthma, and essential hypertension, all of which are influenced usually by the family situation.

Although many types of illness have little or no connection with the family situation, "illness is one form of family maladjustment" (*29a*). This observation was made by Henry B. Richardson, a doctor of internal medicine who collaborated with associates in psychiatry, public health nursing, and social service, in a pioneering study of the family as the unit of illness. After several years spent in establishing the direct connection of disease with specific family situations, Richardson wrote (*29b*):

"The individual is a part of the family, in illness as well as in health . . . The idea of disease as an entity which is limited to one person . . . fades into the background, and disease becomes an integral part of the continuous process of living. The family is the unit of illness, because it is the unit of living."

Sources of Family Data

How do we begin to build up the family data that public health officials can apply?

An immediate, basic task of public health agencies is to improve the reporting of information contained on marriage and divorce certificates. Marriage and divorce are major punctuation marks in family history, as are birth and death. All these events change the characteristics of the population and of the family units within the population. They interrelate with a variety of other material from the decennial census and the current population surveys of the Bureau of the Census and from the special surveys of Federal and State agencies. This material as a whole makes up the benchmark statistics that describe the American family as an institution and as a process. Consumers of marriage and divorce statistics want facts on the formation of new families, on their growth and composition, and on their dissolution. Marriage and divorce statistics are part of family statistics.

The collection of marriage and divorce statistics is a function of the public health agency in most States and in the Federal Government. Generally, it is among the less emphasized functions.

Although some health departments have worked vigorously to improve marriage and divorce reporting, the system on a nationwide basis is relatively primitive and compares unfavorably with that of most other countries of the western world.

No data at all are collected from a substantial number of registration areas in this country; marriage and divorce numbers and rates must therefore be estimated. One of the potential sources of error in these estimates is that in many areas marriage licenses are reported, but marriages are not; the proportion of unused licenses is a fluctuating variable. To take advantage of State differences in legal requirements for marriage and divorce, large numbers of people cross State lines; since reports do not distinguish between temporary and actual residence, the true marriage and divorce rates for any State's residents cannot be determined.

Because certificate information varies from State to State, national cross tabulations cover from 5 to 29 States, depending on the items included in the table. The number of States covered in tables of marriage and divorce characteristics varies not only from table to table but sometimes from year to year, making trend comparisons difficult and area comparisons all but impossible. This appraisal ignores the historical difficulties and the real progress that has been made (*30*, *31*), but discussion of these points is outside the scope of this paper.

In thinking of the potential use of marriage and divorce data as components of family statistics, we should not confine ourselves to the existing fragments, which obviously can have only limited application at present, but instead we should think of what kinds of data might be acquired and applied.

The National Office of Vital Statistics and the American Association of Registration Executives have submitted a proposal to the Association of State and Territorial Health Officers for the establishment of a marriage registration area to be followed by the establishment of a divorce and annulment registration area.

The reasonable criteria for the admission of States to the marriage registration area which were developed by the Public Health Conference on Records and Statistics (*32*) will permit the inclusion of about 26 States at the outset. The objective is the collection of a uniform body of data, consistent for all States in the initial area and eventually for the entire Nation, that will maximize the value of the statistics obtainable from items reported on marriage and divorce records.

But if all this were achieved, the present certificates alone could provide only a fraction of the family data needed. Although the present certificate data are indispensable as a base, there is much more information to be acquired.

How do we go about exploring the potentials in family statistics? The question has special application to the organizations directly concerned with vital and health records and statistics: the statistics section of the American Public Health Association, the American Association of Registration Executives, and the Public Health Conference on Records and Statistics. The initiative should come from vital statistics and records people because they are in the best position to know the possibilities and the limitations of vital records as a source of family data.

Each of us concerned with records on individuals should search for additional items for cross tabulation that would enable us to connect individuals as family members and to connect marriages, births, deaths, and divorces of these individuals as related events occurring in families with particular characteristics.

To serve the statistical needs of public health, it is time we broadened our concepts to include statistics on the family as a unit as well as on the individual. None of us at this stage can be expected to come up with immediate, definitive answers on the specific content of vital certificates, on appropriate technical methods and mechanisms, on the total scope of benchmark family statistics, or on any particular office's proper share of the collection of these data. It will take considerable work and discussion within our organizations to formulate even the first actual steps, but here are some specific lines that seem to be worth exploring.

1. From a family-oriented viewpoint, what can be done to improve the systematic data collection from birth, death, marriage, and divorce records? In reexamining the standard record forms, especially in connection with future revisions, what statistical elements re-

lating the events to the family might be introduced as record items? Would it be valuable to know in what kinds of families deaths from various causes are occurring? Do we want information about successive deaths in families and the composition of the family remnants? What could be done to improve fertility data and child statistics in general through a family-centered approach to the birth certificate? In all of this, the vital statistics system would need the thinking and consultation of health program people at the planning stage.

2. What types of special studies and surveys should be undertaken to enlarge our statistical knowledge of the family in health and disease and to enrich the developing core of vital and health statistics relating to the family? In addition to cross-section studies of family-centered records, we should investigate the feasibility of cohort studies for followup of marriage records and follow-back from divorce records. Moreover, a variety of surveys undertaken for health purposes could be made more valuable if family aspects were considered at the planning stage and incorporated in the study plan. The vital records, perhaps with additional items agreed to by the selected area, might serve as anchor points for such studies.

An urgent research problem is to learn how best to classify families, to determine by limited, short-term studies the kinds of information most essential for characterizing families. Such studies would provide the basis for the collection of family-characterizing data on a larger or a national scale. Without this basic knowledge of the "universe" of American families, the usual study of disease behavior in a selected sample of families cannot be generalized to any known population since there is no way to tell what part of the population the sample represents.

3. In addition to the decennial census, which has always been a rich source of data to students of the family, the current population surveys of the Bureau of the Census are open to special questions on marriage, divorce, and the family structure. They have been used several times for this purpose in the recent past. Questions relating health to the family situation in selected samples could be answered quickly and economically by this means.

4. Hospital and clinic records not only should include questions on the family medical history, as many do at present, but the records for all members of the family might be more accessible as a unit. Exploration of the objectives and technical problems might well be undertaken jointly by vital statistics people and medical record librarians.

5. Similar potentials exist in public health nursing records, which routinely contain data on the family, and which for special study purposes might profitably be collated with birth, death, and marriage records.

From a public health standpoint, the family is not just a social unit, it is an epidemiological unit. Study of the family requires an interdisciplinary approach of classical epidemiology and the social sciences. The statistical technique, for want of a short and simple term, might be called "social biostatistics," to which family-oriented vital statistics would contribute a share of the basic data.

A final quotation from Richardson is appropriate (*29c*):

". . . we may now consider how to develop a science of the family. The language in which this science will be expressed will not have the precision of mathematical analysis, unless on a statistical basis. Much of the material, as in many of the natural sciences and in psychology, will remain on a descriptive level. Nevertheless we may hope to develop an understanding of the family unit, which will help us to predict the future course of events."

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THE FAMILY

A FOCAL POINT IN HEALTH EDUCATION

Last April, the 16th Eastern States Health Education Conference at the New York Academy of Medicine dealt with the family as a "focal point in health education." But the main emphasis was on the family as a focal plane for health practice, as a basic ingredient of the social process. The program talks and lively discussions were sparked by questions and comments from the floor, as the audience discovered new resources and unsuspected peaks and valleys on what had been thought to be familiar terrain.

The full text of the papers offered is to be published by the academy, under editorship of Dr. Iago Galdston, secretary of the Committee on Medical Information. Dr. Galdston also is secretary to the conference committee, headed by Dr. Herbert B. Wilcox, chairman. He will welcome inquiries or suggestions with respect to this conference or future ones. The address is 2 East 103d Street, New York, N. Y.

Public Health Reports is publishing briefs intended to touch upon a few of the salient issues suggested by the speakers. This treatment necessarily omits essential background discussion and illuminating details. The charts which appear in this conference report were among those given the delegates in the statistical survey prepared by Edward A. Lew.

A paper by Dunn and Gilbert discussing the need for improving family statistics for public health applications precedes this section (pp. 1002–1010).

Evolution of the Character Of Family Life Education

PHR brief

In a book published in 1881, "Gems of Knowledge," Dr. Paul Barrington wrote that women have as much right as men to choose a life companion. This—and other statements in a similar vein—contrasted sharply with the Victorian view of women as chattel and the family as an institution for the pleasure and comfort of men. A new point of view was emerging—a point of view that recognized the need for study of the family and its members and the values of education for personal and familial living. What has happened since Dr. Barrington's day may be traced in the accompanying list of significant events.

In the beginning, organized interest was centered on some particular member of the family or some special aspect of family living: children, mothers, or sex, for example. No thought was given to the family as a whole. During the 1920's and most of the 1930's, the focus was on children and how they could be taught habits and how best to discipline them. Family relationships were reduced virtually to a set of rules.

The 1920's saw the beginning of courses in family living in colleges, but what gave generalized family life education one of its biggest boosts was the change in the concept of education itself. High school was recognized as the privilege of everyone and therefore a key place for education for marriage and family life.

Originally, family life courses in high schools concentrated on generalizations about the family, but the youngsters were not content with this. They wanted their questions answered, questions about sibling rivalry (though they wouldn't use those words), petting, or going steady. Thus, the discussion technique in family life courses evolved, and with it, the need for teachers trained in the subject.

Concurrently, parents, too, sought to find answers to family issues. General interest in the family court concept in the late 1930's showed that the legal profession was beginning to think

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Significant Events

1877. Family service agency established in Buffalo in recognition of the need for casework services for the whole family.

1888. Child Study Association of America founded in New York by a group of parents who wanted information on how to bring up their children; Association for Child Study and Parent Education organized in Chicago by a group specifically interested in child psychology.

1896. National Congress of Parents and Teachers founded for the study of the child at home and at school.

1911. Family Welfare Association of America organized to bring together persons and agencies engaged in family casework.

1914. Family court established in Hamilton County, Ohio; American Social Hygiene Association founded to promote "those conditions of living, environment and personal conduct which best protect the family as a social institution," with emphasis on suppression of prostitution and reduction of venereal diseases.

1918. Federal funds made available to the States for venereal disease control and education.

1922. Federal funds made available to the States for maternal and child health programs.

1925. Marriage preparation and family living courses introduced at the University of North Carolina.

1938. National Council on Family Relations organized to provide a meeting ground for all who share in helping the family solve its problems.

1951. American Social Hygiene Association began expanded programs in education for family life; projects aimed at teacher preparation for family life education courses started soon thereafter.

of the family as a unit. And about the same time, family welfare agencies, once absorbed in relieving cold, hunger, and the need for clothes and shelter, began to broaden their services.

Dogmatic Opinion to Objectivity

During the early days, each piece of educational literature contained a heavy dose of moralizing based on Victorian ideals. Shortly after the end of World War I came the fault-finding and finger-shaking approach which tended to favor the child-centered home and to find fault with the parents. Articles in slick-paper magazines carried such titles as "1, 2, 3 for Better Parenthood" or "Temper Tantrums? You're at Fault!"

In recent years, research has produced a greater degree of objectivity, and it has challenged many of the earlier assertions. For example:

1. Three studies refute the notion that fathers are of diminishing functional importance in the personality development of American children.
2. Three studies fail to support the idea that interfaith marriages are less likely to be happy than marriages of those of the same faith.
3. Conflicting findings in dozens of investigations challenge the idea that personality development is adversely affected if a child is an only child.

Another trend apparent in the family life education movement is that from personal or neighborhood concern to professional concern supported by charitable foundations and universities and to public concern backed by Federal, State, and local funds. Interest was first exhibited by groups of parents who wanted to learn how to rear their children. Early support for research came from foundations and was carried out at universities. Family life courses were first introduced in colleges.

Opportunities Unlimited

Health agencies have countless opportunities to participate in the movement for generalized family life education. Many aspects of the prevention and control of disease and the promotion of health can be approached effectively through the family framework. Nutrition, for example, is more than vitamins and proteins or calorie charts. It is the food customs of families that help give a larger purpose and meaning to mealtimes. Cancer is more than a question of early symptoms and the search for a cure. It is the adjustment of a family to a crisis, a test of its stability.

Changing Family Profile

PHR brief

The profile of the American family has changed markedly in the past 15 years.

More persons than ever before live in families. Americans are marrying earlier in life. The level of births continues to set new high records each year. And family size shows an upward trend.

Living in families are 94 percent of the population, with an average of 3⅓ persons per household.

The number of families has increased 28 percent, from 32,166,000 in 1940 to 41,202,000 in 1954, or almost one-fourth more rapidly than the total population (table 1).

Husband-wife families have accounted for almost the entire increase. The number of married couples in 1954 exceeded 37,300,000. And all but about 1.5 million had their own households, reflecting a considerable decrease in doubled-up families prevalent during the war years.

It is significant that married couples represent 7 out of every 8 families with their own households. Of the other than husband-wife families, approximately 3 out of 4 are headed by a woman, denoting mainly that there are many more widows than widowers and that many husbands are serving in the armed forces or are away from home for other reasons.

The marriage rate, which spurted to an all-

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Table 1. Family units in the United States, 1940 and 1954 [1]
(numbers in thousands)

Type of unit	Total	Own household	Type of family		
			Husband-wife	Other male head	Female head
	Units, 1940				
Families	32, 166	----------	26, 971	1, 579	3, 616
Primary	31, 491	31, 491	26, 571	1, 510	3, 410
Subfamily	2, 062	----------	1, 546	[2] 56	460
Secondary	675	----------	400	69	206
Unrelated individuals	9, 277	----------	----------	4, 800	4, 477
Primary	3, 458	3, 458	----------	1, 599	1, 859
Secondary	5, 819	----------	----------	[2] 3, 201	2, 618
All types	----------	34, 949	28, 517	----------	----------
	Units, 1954				
Families	41, 202	----------	36, 041	1, 336	3, 825
Primary	40, 961	40, 961	35, 875	1, 326	3, 760
Subfamily	2, 107	----------	1, 305	98	704
Secondary	241	----------	166	10	65
Unrelated individuals	9, 700	----------	----------	4, 075	5, 625
Primary	5, 932	5, 932	----------	1, 904	4, 028
Secondary	3, 768	----------	----------	2, 171	1, 597
All types	----------	46, 893	37, 346	----------	----------
	Individuals in units, 1954				
Families	147, 953	----------	[2] 131, 784	[2] 4, 125	[2] 12, 044
Primary	147, 248	147, 248	[3]	[3]	[3]
Subfamily	[2] 5, 920	----------	[3]	[3]	[3]
Secondary	705	----------	[3]	[3]	[3]
Unrelated individuals	9, 700	----------	----------	4, 075	5, 625
Primary	5, 932	5, 932	----------	1, 904	4, 028
Secondary	3, 768	----------	----------	2, 171	1, 597
All types	157, 653	153, 180	131, 784	8, 200	17, 669

[1] Excludes inmates of institutions; 1954 also excludes all but 822,000 members of the armed services.
[2] Estimated by the Statistical Bureau, Metropolitan Life Insurance Co.
[3] Not available.

SOURCE: Bureau of the Census.

DEFINITIONS: *Family*—group of two or more persons related by blood, marriage, or adoption residing together. *Primary family*—embraces all the persons related to and including the head of the household. *Secondary family*—head of household is not related to the family sharing his dwelling, such as a group of roomers or resident employees. *Subfamily*—a married couple with or without children, or one parent with one or more children under 18 years, living in a household and related to, but not including, the head of the household or his wife.

time high of 16.2 per 1,000 population in 1946 upon demobilization, has since been declining. In 1955 the rate was 9.3 per 1,000. It is not expected that the number of marriages will vary greatly for several years to come. After the early 1960's, however, there should be a marked upsurge when the large number of babies born during the war and postwar years begin to reach marriageable age.

Early Marriages

The trend toward early marriage is equally marked for both men and women. In 1955 more than 14 percent of all girls at ages 14–19 had been married compared with only 10 percent in 1940. At ages 20–24 the corresponding proportions for women were 71 percent in 1955 and 53 percent in 1940 (table 2).

Slightly more than half of the men at ages

20–24 are now married, or have been, compared with only 28 percent in 1940. At ages 25–29, the proportion now is 72 percent compared with 64 percent in 1940.

The median age of men at first marriage is only about 23 and that of women barely 20.

A study recently made by the National Office of Vital Statistics of the Public Health Service points out that 1 in 3 couples marry on a "shoestring," with an income of less than $60 a week.

Currently, about 11,800,000 married women, 29 percent of the total, are in the labor force. While it has long been customary for young wives to work until the baby came, recently more and more of them are returning to the labor market as the children grow up. Thus, about a third of all wives at ages 35–54 now work outside the home; for the younger women the proportion is about one-fourth. The fact that 2 out of 3 married women live in urban areas enables them to take advantage of employment opportunities.

The Baby Boom

Even more remarkable than the recent increase in the married population has been the continuing boom in babies. Since the close of World War II, births have averaged 3,800,000 annually, with each of the past 5 years successively establishing new high records. Almost 4,100,000 babies were born in 1955, the equivalent of a rate of 24.9 per 1,000 population.

Accounting in part for the unprecedented number of babies born in recent years is an almost uninterrupted rise in fertility from its low level in the 1930's. In each of the postwar years, about 1 out of every 6 married women under age 45 bore a child, whereas in the mid-1930's the proportion was only 1 in 8.

The rate for first births began to climb immediately after 1933 and spurted sharply in 1941 and 1942. Demobilization brought an even greater jump in the birth rate of first babies in 1946 and 1947.

The upward trend in the birth rate of second and third babies since the beginning of World War II has raised such birth rates to considerably higher levels than those prevailing in the 1920's. Since about 1951 there has also been a definite rise in the birth rate of fourth and fifth children. This trend certainly presages a return to moderate-sized families, but it is not likely that families will become as large as those 50 years ago.

The high birth rates of the past decade are, of course, reflected in the proportion of families with dependent children, particularly among the younger married couples. A large proportion of families have a child within 5 years

Table 2. Percent ever married according to age, by sex, United States, 1890 to 1955

Age group, years	1890	1900	1910	1920	1930	1940	1950	1955
	Males							
14–19	0.4	0.9	1.0	1.8	1.5	1.5	2.9	2.9
20–24	19.1	22.1	24.5	29.0	28.8	27.8	41.0	51.2
25–29	53.9	54.0	57.0	60.3	63.1	64.0	76.2	71.9
30–34	73.3	72.2	73.7	75.7	78.7	79.3	86.8	85.1
35–44	84.5	82.9	83.1	83.7	85.6	86.0	90.4	91.1
45–54	90.7	89.6	88.7	87.8	88.5	88.9	91.5	91.5
	Females							
14–19	8.0	9.4	9.7	10.8	10.9	10.0	14.4	14.2
20–24	48.1	48.3	51.4	54.3	53.7	52.8	67.7	70.9
25–29	74.6	72.4	74.9	76.9	78.2	77.2	86.7	88.4
30–34	84.8	83.3	83.7	85.0	86.7	85.3	90.7	92.9
35–44	90.1	88.8	88.5	88.6	89.9	89.6	91.7	93.1
45–54	92.8	92.1	91.3	90.3	90.8	91.3	92.2	93.2

SOURCE: Bureau of the Census.

Table 3. Child dependents among married couples according to age of husband, United States, 1940, 1950, 1953

Age of husband (in years)	Percent with one or more own children under 18 years			Own children under 18 years per married couple with children	
	1940	1950	1953	1950	1953
14 and over	58. 1	54. 6	55. 7	2. 07	2. 15
14–24	49. 4	56. 1	61. 2	1. 41	1. 57
25–34	69. 2	76. 4	80. 0	1. 94	2. 13
35–44	76. 2	77. 5	79. 4	2. 40	2. 41
45–54	59. 3	49. 2	37. 6	2. 03	1. 98
55–64	34. 8	19. 5		1. 77	
65 and over	17. 1	5. 1	4. 6	1. 61	1. 70

SOURCE: Bureau of the Census.

of marriage. The average number of children per family has also increased appreciably where fathers are under 35 years of age (table 3).

Children under 18 years of age now number nearly 57 million, an increase of 15 million in the 11 years since the end of World War II. This increase has broken all previous records and is greater, in fact, than the gain in the preceding half century.

The total number of children is expected to continue to climb, and by 1965 it is estimated that there may be upward of 65 million children under 18 years in the United States. This would mean a somewhat larger average family than we have now.

Currently, close to 8 million children under 18, almost one-seventh of the total, live with only one parent or with neither, mainly because of family disruptions through death, divorce, or separation. Of these, almost three-fifths live with their mother, about one-tenth with their father, and the remainder under a variety of other arrangements, mainly other relatives.

The problem of orphanhood has been diminishing, but about 1 percent of the children under 5 years, 9 percent at ages 10–14, and 14 percent of those at ages 15–17 are orphaned.

Widowhood

Even though the number of widows in the population has been mounting rapidly, the proportion of women who are widows has been decreasing at every period of life. This is mainly the result of the decline in mortality.

Of the 7,600,000 widows, more than half are 65 years of age or older; two-fifths are in the age range 45–64, and less than one-tenth are under 45. Many of the widows in the younger age brackets have dependent children in their care (table 4).

Although widowhood has been increasingly

Births per 1,000 married women aged 15–44 years, by order of birth, United States, 1920–54.

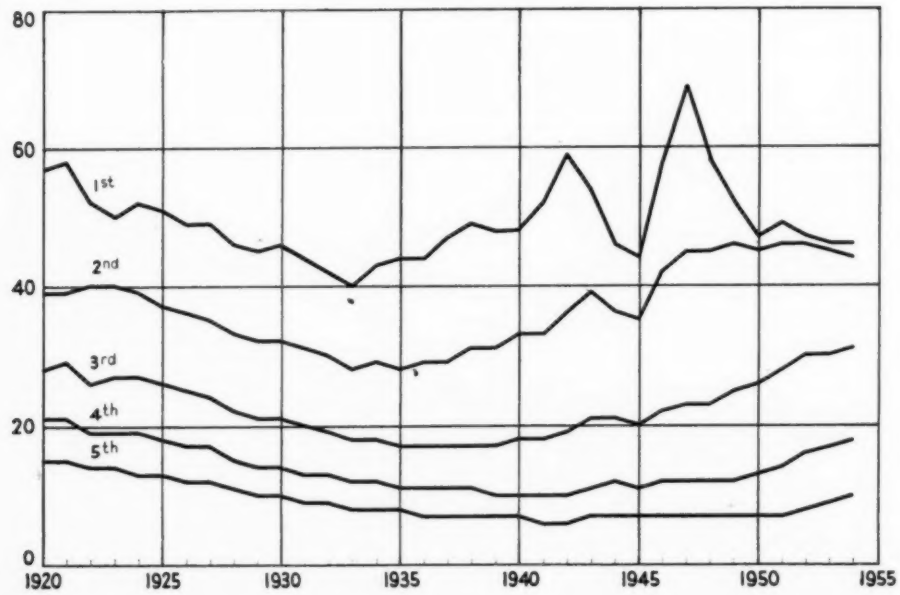

Table 4. Widows in the United States, 1930 and 1955

Age (in years)	1930 (4,734,374)		1955 (7,595,000)	
	Percent of all widows	Percent of all women	Percent of all widows	Percent of all women
14–44	18. 3	2. 9	7. 6	1. 6
45–54	18. 5	14. 0	13. 5	10. 8
55–64	23. 7	27. 8	24. 9	25. 6
65–74	23. 9	49. 0	30. 6	46. 5
75 and over	15. 6	73. 9	23. 4	70. 9

SOURCE: Bureau of the Census.

postponed to the older ages, it remains nevertheless an important social and economic problem. About 1 woman in every 2 who now becomes a widow before age 60 has 20 or more years of life ahead of her. Nine out of every ten widows live either in their own homes or with relatives. Of the remainder, about one-half live as lodgers or as resident employees; one-fourth live in hotels or similar places, and an equal number in homes for the aged or other institutions. Many widows past the prime of life are in the labor force.

Psychological Dynamics Of the Familial Organism

PHR brief

A new prototype of the American family is emerging from the steadily changing patterns of family organization.

There is the changed position of women in society, their new role in industry, their achievement of equal rights with men, their sexual awakening and emancipation. Also there is the removal of the working father from the home,

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the mother's expanded domination of home and children—the whole tradition of "momism." With all this has come an inevitable shift in the relations of men and women, and in child-rearing attitudes. The homestead has been stripped of the traditional functions of work, religious worship, schooling of the children, and care of the sick and aged.

The values of self-selection of mate, of compatibility in marital relationships, and of child-centered family life are accentuated. But the increased freedom, while promoting greater creativeness, also induces confusion and turmoil in family roles. What a man expects of a wife and what a wife expects of a husband has become complicated by a multiplicity of needs, many of which are contradictory in nature.

Unit of Diagnosis—the Family

Many persons and many families feel insecure, confused, and isolated in their community position. They perceive these rapidly changing social patterns as menacing and as a withdrawal of support. Young parents, separating themselves from the older generation but failing to find a substitute in the wider community, feel alone and adrift. They undergo personal torment in searching out an appropriate path. Their torment intensifies the strain in family relations and imposes an additional burden on the family's inner life. The family then tries to compensate to an exaggerated degree for the individual's lack of security in the wider community by providing a protective barricade against what often seems to be a cold, harsh outside world.

The experience of the modern family underscores the fact that accurate psychiatric evaluation and effective treatment of individual patients is simply not possible unless the disturbances of these individuals are defined in the context of their emotional position in their family. The family is the unit of growth and experience, and therefore the unit of health and illness. There must be a shift of interest from the individual as the unit of diagnosis and therapy to the family group as the unit of diagnosis, therapy, and prevention.

Clinically, the first person to seek psychiatric help may prove to be either the most or the least

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sick member of the family. In evaluating the primary patient, it is important to trace the lines of significant involvement with other family members and to judge the illness as a reflection of the level of the family's emotional functioning. It is important, too, to discern in the arena of family life where lies the most critical focus of conflict and anxiety, to determine whether the core of the disturbance rests in the illness of one member or in the conflict of a particular family pair. Or does the conflict pervade all family relationships? In this sense, the behavior of one member may be interpreted as a symptomatic reflection of the emotional distortion of the entire family.

Basic Principles of Diagnosis

A system of family diagnosis calls for the evaluation of the group patterns of the family, the personality dispositions of each member, and methods of correlating individual experience and group interaction. Three empirically documented principles are relevant toward evolving such a system.

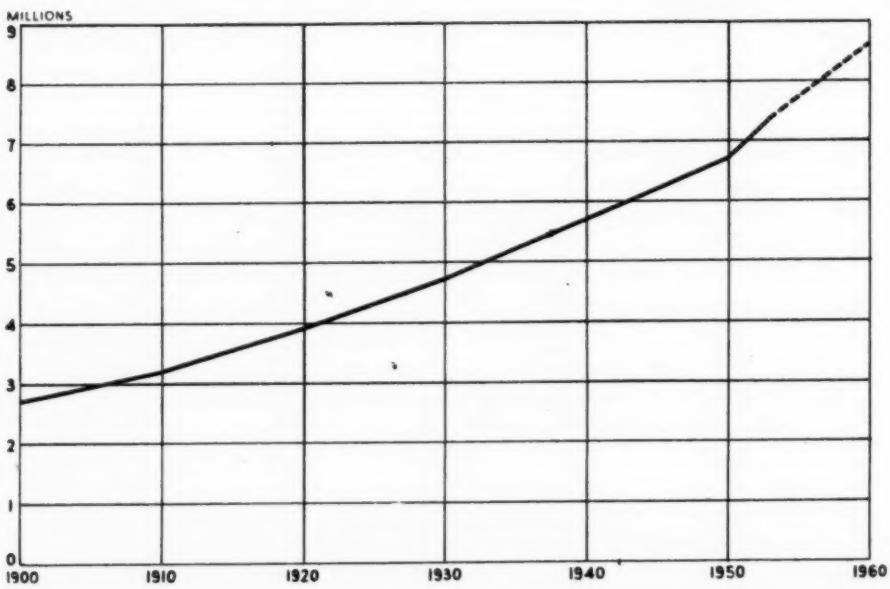
1. Abnormal behavior in adult persons is significantly rooted in the experience of childhood integration into a particular family, but continues to be molded by current family experience.

2. The diagnostic evaluation and therapy of emotional disturbance in a child, viewed as an individual apart from his family environment, is impossible. The proper unit for study and treatment is the child seen as part of the family, the family as part of the child.

3. Personality disorder and disturbances in social adaptation of adult persons may be better understood if examined not in isolation but as a dynamic changing pattern influenced continuously by the reciprocal effects of family interaction. Deviant behavior is thus seen not merely as a projection of fixed intrapersonality distortion but also as a functional expression of emotional interplay in significant personal relationships. The way in which the person perceives the image of others influences his image of self and vice versa. This two-way process continuously molds feeling, attitudes, and action.

Personality, born and bred in the social matrix of the family, and family and culture may be regarded as behavior systems existing at different levels of experience, each interdependent although interpenetrating parts of a whole which change and shift over time. Stability within the person and stability in the relations of persons and environment are mutually contingent, and the life and growth of the individual are inconceivable except within the group.

Number of widows in the United States, 1900–1953, and forecast for 1960.



The interrelations of individual behavior and family relationships need to be scrutinized in three dimensions: the group dynamics of the family; the dynamic processes of emotional integration of the individual into his family role; and the internal organization of individual personality and its historical development. The phenomena of family role constitute the bridge between the internal processes of personality and the group pattern of the family.

Purposes Served by Family

The family serves biological continuity by providing a socially supported group pattern for the sexual union of man and woman and a quality of parental partnership essential to the care of the young. The family is literally the cradle for the infant's tender mind as well as his body. Concretely the purposes served by the family are:

To provide food, shelter, and other material necessities which sustain life and protect it from external dangers; to form a matrix for the affectional bond of family relationships; to give opportunity to evolve a personal identity, tied to family identity, which supplies psychic integrity and strength for meeting new experiences; to set the pattern of sexual roles, preparing the way for sexual maturation and fulfillment; to establish social and ethical standards for social roles and acceptance of social responsibility; to cultivate learning and support individual creativity and initiative.

One important feature of family identity is its stability, its internal capacity for self-regulation and for restoration of a state of balance following an upset. There are at least two kinds of stability. One is characterized by resilience and capacity for accommodation to change and the other is marked by a rigidity toward change. In the meeting of new problems and crises, some families are weakened and others grow in solidity and emotional strength. Some families grow and learn from experience; others seem unable to do so because they are too inflexible and tend to disintegrate.

Families differ in their capacity to restore emotional balance. If this balance is not restored after disturbance, the inevitable consequence is a breakdown in emotional communication and empathy, increasing alienation in family ties, and confusion and impairment of family identity.

The interrelations of marital and parental identity and individual identity are delicately balanced. In a healthy family, out of the fusion comes a richer, stronger individual identity. The differentiation of the separate self is as important as is the basic family unity. The quality of difference in a family member need not be felt as a threat, any more than sex difference is a threat. Instead it should be welcomed as proof of the complementation of the self, the opportunity for new learning and greater fulfillment.

Mental health cannot be conceived in "all or none" terms. In emotional terms, people are neither wholly sick nor wholly well. Since mental health is largely a function of social processes, the more suitable test is the individual's integration into his group, rather than his personality structure defined in abstract terms. Surely mental health signifies the absence of mental illness, but it is much more than this. It implies confidence, courage in facing new experience, the capacity to grow, to learn, to live fully, to love and to share with others the adventure of life—in other words, a concern for the common good.

Family Health Maintenance

PHR brief

Social agencies have known for years that they must reach families before social and emotional disorders become fixed. The broken home, the vanished parent, the child in custody, all underline the fact that agency jobs are salvage jobs. Trends in medicine have coincided with trends in social welfare, and there has been a growing awareness of the interplay of social factors and

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disease. Molding the environment, health promotion, and prevention of social illness must be combined with treatment of all disease.

The organization of medical care for the family must consider its needs, modern knowledge of prevention and treatment in both the physical and the socioemotional fields, and the cost—the cost of organizing health service and the cost of not organizing it.

A research demonstration in health promotion and preventive medicine is being conducted at Montefiore Hospital under the joint auspices of the hospital, the Columbia University College of Physicians and Surgeons, the Community Service Society, and the Milbank Memorial Fund.

Selected at random from the Montefiore medical group of the Health Insurance Plan of Greater New York are 150 families and an equal number of matched controls. Advantages and disadvantages of participation in the study were discussed frankly with all participants because, while it was important to get as many families as possible to cooperate, it was equally important that these families continue participation to the end of the program. The controls responded to a long and time-consuming questionnaire in approximately the same proportions as the study families participated in the demonstration.

Evaluation

The information collected from the families is to be used as baseline data. From this information an evaluation schedule is filled out and a numerical score is given to each individual in 11 different areas. At the end of the 4-year study period, similar information schedules will be completed and evaluation forms will be filled in. From these, the study families can be compared with themselves and with each other as well as with the control families, who will have a final evaluation of the same order.

No equally comprehensive initial evaluation was made of the control families. However, they have filled in a Cornell medical index and supplied housing and nutritional schedules. We have physical examination reports in their HIP charts, also.

The Health Team

In the demonstration, the health team is composed of a physician, a public health nurse, and a social worker. Medical care, preventive medicine, health education, health promotion and guidance, and psychiatric advice and some psychiatric help are the elements of the team's functions.

Medical consultants aid in diagnosis and treatment through the matrix of medical group practice. A social scientist consultant offers specialized skills in diagnostic and treatment methods appropriate to social factors, social disability, and social disorganization. A psychiatrist, a psychologist, and a health educator also serve as consultants.

The decline in numbers of general practitioners and the increased medical knowledge, diagnostic and therapeutic equipment, and skill have necessitated a medical adviser who is closer and more accessible to the family than the specialist. Fortunately, a link between doctor and patient is already in existence. Public health nursing and medical social work arose in response to such a need. With changing attitudes of physicians and loss of rapport between doctor and patient, public health nurses and social workers have been developing in skill and numbers. In the demonstration, the new, important aspect of their roles is prevention—to reach into families before disaster strikes.

The public health nurse herself shares in many areas of the doctor's role that deal with preventive medicine in the areas of nutrition and health teaching. In the area of interpersonal relationships, the social worker has become the professional practitioner, helping patients to understand their problems, providing access to other agencies and sources of care, and "shoring up" the emotionally sick and the socially disabled.

The health team can act as the family's guide and adviser because it has information, authority, and the confidence of the patient. Internally, the team must operate with mutual confidence. The Montefiore team has no captain; decisions reached in conference are referred to the person with competence in a given area or to the person with whom the patient has the closest relationship.

Whether physical or emotional, preventive or therapeutic, individual conferences, group discussions, or consultations with parents about themselves or their children, action requires the resources of the entire team.

One important function of the health team is the service it can give in emotional upsets. However, a consulting psychiatrist orients and supervises the team members, inculcating psychiatric attitudes, information, and some techniques. He helps the team members to use the new skill to improve their own functioning and to add a new dimension of help to the patient.

The consulting psychiatrist does not actually perform services for patients. In weekly conferences with the team members he offers general information on psychodynamics, on patterns of behavior, and perhaps on a specific case or family. His social usefulness is enhanced many times by this means, and it may be that only through such organized service as a health team with a consultant psychiatrist will it be possible to bring the mental health approach into the medical care system.

Basic Hypotheses

Definitions of such terms as "health," "anxiety," "help," "guidance," and "support" were agreed upon early in the demonstration.

"Health" was defined as "harmonious functioning" in various facets of living. Emotional health is intimately tied to family relationships. Parents represent a profound influence in the health, or harmonious functioning, of the child and, consequently, of the adult since, as stated by Bowlby, "the form our family relationships take when we are grown up are, to a high degree, dependent on the form they took in our early years, and the very first relationship we make—that with our mothers—is the most important of all." The causes of failure in marriage often lie in family stress in the previous generation. Realization of this cyclical quality of emotional disturbance led us to concentrate health promotion efforts on providing parents with some knowledge and understanding of defects in their marital relationships, not to assess damages against them or their children.

In the early part of the study, more than half of the reports of doctors and social workers noted "anxiety" among family members. The term needs clarification. Anxiety as a response is useful and necessary, provided it is not more than the stimulus warrants. Our concern is with types of anxiety in which the response is disproportionate to the stimulus and interferes with an individual's effective functioning in all areas of living.

This concern for emotional disturbances is within the family setting, and it is within the family setting that maximum effort should be concentrated. However, stresses such as low income, prejudice and segregation, and national and international political tension must also be weighed and considered in evaluating help for the family.

The demonstration is concerned with giving "help, guidance, and support" in physical as well as in emotional stability and growth. Injections and vaccinations are given against contagious disease. The public health nurse attempts to provide the latest information on nutrition, particularly to pregnant women. Poor or inadequate housing is dealt with as constructively as possible.

Health Education

A variety of personal and group educational approaches are used in maintaining family health. These include conferences, literature, informal discussions, and group discussions. Family conferences, in which parents meet the whole health team, are valuable. After the initial study and evaluation of each family are completed, a schedule or plan for health supervision is discussed in conference between the family and the health team. The knowledge that this group of professional people is concerned and interested and is offering suggestions is very gratifying to the family.

Although attendance at group meetings was not large, the health team was gratified to be able to reach even a small proportion of the study families. Some of the reasons suggested for the small attendance are competing entertainment and the accessibility and perhaps repetitiousness of educational forums in schools, churches, and neighborhoods. Ease of access to individual conferences also may militate against attendance at group discussions.

The Physician And the Family

PHR brief

The character of the professional relationships of a physician both with the families of his patients and with his associates in health education and family care will be affected directly by the kind of education he receives in medical school. Recently developed teaching projects designed to advance the practice of health education in family living are evidence of a trend toward educating the physician to understand the health of the patient in relation to the family environment.

The origins and reasons for this movement are complex; their contributors, both individual and organizational, are many. In the past quarter of a century, the Association of American Medical Colleges particularly has emphasized the importance of appraisal of social and environmental factors in clinical teaching. The 5-day teaching institute held in 1952 by the Conference of Professors of Preventive Medicine and the Association of American Medical Colleges at Colorado Springs, Colo., gave considerable impetus to the further expansion of comprehensive medical care teaching demonstrations, with emphasis on home and ambulant care.

Of interest is the extent to which departments of preventive medicine have a responsible role in this form of extramural teaching, the appearance of psychiatry in a consultative teaching function on behalf of other departments, and new administrative arrangements and purposes in the relations of clinical departments for the demonstration of medical care. The Cornell comprehensive care and teaching program and Boston University's domiciliary medical care program are good examples of the latter.

By Duncan W. Clark, M.D., professor and chairman, department of environmental medicine and community health, College of Medicine, State University of New York, New York, N. Y.

The State University Project

As a learning device and as a form of service, the value of simultaneous appraisal of all members of a household has been demonstrated in the Family Health Study Program of the State University of New York College of Medicine at New York City. This family medical and social appraisal is the major project of a 1-month full-time clerkship in environmental medicine and community health carried on at the health department's Red Hook-Gowanus District Health Center in Brooklyn, N. Y. Each senior medical student is assigned a family chosen for the program by the health center's community nursing service and as much of the study as possible is conducted within the family home in a series of frequent visits.

Physicians, social workers, public health nurses, social scientists, and staff of community agencies serve as consultants to the student and evaluate his findings with him individually and in groups. The recommendations found most acceptable in the joint conferences are acted upon by the public health nurse in the further use of community agencies for continuing care.

The totality, size, and concentrated time span of the family studies of this program differ notably from what is usual in family medical practice where the physician's contact with a family is usually episodic and in response to a call for the care of the family member who is ill. In the State university study program all family members are equally the object of attention in the same time period. Some of the examinations performed go beyond those commonly made by a practicing physician; for example, after the student-family relationship has become stabilized, examination may be made of the home to discover hazards that might cause accidents.

The Student's Appraisal

In making his report, the student appraises each member of the family at three levels, according to the individual's personal health, the latter's role in and relations with other mem-

bers of the family, and his role in and relations with the community itself. The need of reducing the record to diagnostic and summary terms leads into the consideration of several general questions of instructional importance. One family's history illustrates two such questions: (*a*) the problem of selecting the initial steps and the frequently limited goals possible in aiding the restoration or promotion of family functioning and personal health and (*b*) the opportunity of examining the family for identification of diseases which have a familial risk.

The husband, an unskilled laborer, had been unemployed for a year. He had asthma and bronchitis, and official agencies were about to investigate the possibility that these conditions were sufficiently disabling to justify the transfer of financial support of the family from the category of home relief (for the fully employable) to that of aid to dependent children. He was found to be depressed, showed striking symptoms of self-devaluation, and his relations with his wife had deteriorated to the point of consideration of divorce.

Although the wife had not handled the family funds when the husband was the provider, she had since taken over the handling of public assistance funds. She seemed competent as a mother, but her ability as a wife was more open to question. Perhaps childhood illness and experiences, or the lack of much of a childhood—she had worked in a factory from age 8 to 18 years—may have qualified her ability to relate on a mature level.

A problem such as the unemployment of the head of the family offers a series of choices in the attempt at solution. Determined agency activity in finding the husband a job might restore his status again as the main provider and head of the household. Referral of the wife to a family agency for a fuller understanding of her situation and of her attitudes toward her husband and even of her version of his behavior might identify which adult member in the family is the better able to form a relationship. Or the husband might be referred to a psychiatrist for an examination to determine whether his behavior is evidence of a psychological disorder that may disqualify him for work or for certain kinds of work.

The nature of the training and experience of health personnel may be the main determinants of the choice of one of these directions toward more healthful functioning. The physician, the social worker, and the public health nurse each select a different approach to this family's problem. Further, there are times when vocational advice may require inquiry into the health status of family members and understanding of family relationships.

Family Disease and Familial Risk

In the care of an individual or family a doctor's concern must include attention to resistance and susceptibility to disease. Ideally, in a full appraisal and in anticipating susceptibility to disease, inquiry needs to be extended to all relatives, living and dead, to pregnancies unfulfilled, and even to the yet unborn. Such a case study approach will provide students and teachers with data for a discussion of existing knowledge, or lack of knowledge, of the mechanisms of disease as influenced by genetics and by environment.

As a teaching device we may conceive "family disease" as multiple cases of a disease among relatives or single cases of disorders known to carry a "familial risk" to children. In the family mentioned previously there were two likely instances of disorders associated with familial risk to children. The mother had dextrocardia and 1 of the 5 children had epilepsy. Two maternal aunts and the maternal grandmother had gallstones, but it is not known whether the mother had gallstones as well. She had eclampsia on one occasion and her mother had hypertension. Little of significance can usually be drawn from the history of more distant relatives. On the subject of disorders known to be common, there were nutritional deficiencies, and these were presumed to be due to the family's marginal economic circumstances.

The term "familial risk" denotes an empirical observation without the usual assumption of genetic etiology. Families share common environments as well as common genes, and families in consecutive generations show some tendency to remain within the same cultural, religious, and economic groups. In the family studied, two possible familial risks were present, epilepsy and dextrocardia. Because the

parents in this family were cousins, the question was pertinent whether children as yet unborn to this marriage might be heir to dextrocardia. However, since as many as five children had been born without this rare congenital defect there is little probability of a later child having the condition.

Attitudes Affecting Counseling

The possible role of personal and professional attitudes in counseling may be illustrated in a study of a family of four. The father had advanced pulmonary tuberculosis, one child had recently recovered from chorea, and the other child had had rheumatic fever for 2 years and had been in a special institution for this disease. The mother had gone to work 6 months earlier, at the time of her husband's hospitalization. There had been no untoward consequences to the children with the mother at work, but the question was raised speculatively in conference whether she should have made this decision.

The 16 medical students unanimously agreed that the mother should have gone to work. But medical students believe in hard work, and they have a strong pragmatic streak. After all, they seemed to say, the woman had been working for 6 months with no serious consequences to herself or her children.

The intended implication of the question was what response representatives of special fields might make to the question of the advisability of the mother's employment, according to their professional knowledge and orientation. The following responses might have been made.

A pediatrician might be primarily concerned with the fact that two young, recently convalescent children were unattended on their return from school.

A psychiatrist might feel that the wife's pursuit of work, while relieving anxiety in her, could have an emasculating effect on the husband and could pressure him to a premature return to work.

An anthropologist might say that it is traditional for Puerto Rican women to work hard and that the mother's employment was a decision acceptable to both sexes of this ethnic group.

An internist might feel that prevention of tuberculosis in the mother is the critical issue and that her undoubted recent exposure to the disease should weigh against her working, although his opinion might be based more on clinical prudence than on possession of the facts on the role of work.

Education for Parenthood

PHR brief

Modern education for parenthood centers around the family rather than the mother and her infant. Today's classes for families expecting another child now include not only the father but the children, offer shared learning for the greatest sharing experiences in life, seek to expand the boundaries of family feeling, and foster an environment conducive to psychic growth for parents and children.

Apparently, the enthusiastic response to our classes at the Maternity Center in New York City and in other large centers of population coincides with a widespread desire for help. Our classes consistently attract more applicants than there are chairs available. Sometimes, young couples apply even before a child is expected.

In part, we attribute the favorable response to the fact that young couples wish to be equal to parenthood. They feel a need to develop their inner resources. They wish to learn what changes to expect in their relationship to each other and in their pattern of living.

Few youthful parents know what they should about human reproduction. Although the majority in our classes have attended college, they have little real knowledge of how a baby is born. Confronted with the process of birth, they wish to understand rather than wonder. Those able to assimilate medical knowledge seek the help of experts. But rather than imprecise answers,

By Hazel Corbin, R.N., general director, Maternity Center Association, New York City.

they seek facts from which to make their own decisions. They are not willing to accept a passive role. This attitude is perhaps more crystallized in maternity care than in other medical services.

Only 25 years ago, emotional security was a concept limited to psychiatrists and other professional workers. The parents of today, conscious of their own personality disturbances, try to create a good emotional climate for their children. They are irrevocably committed to the momentous adventure of parenthood, and they are unsure of their ability to live it well. They need not only to learn the elements of bathing and diapering an infant. They need help also in understanding their own and the baby's behavior. They wish to avoid the mistakes they feel their parents made unwittingly.

Unlike their parents, who often felt they had to possess a house and car before they could afford babies, today's young people base their security on the family and its social value rather than on material things. Whatever adds social value to the family strengthens their sense of security. Since formal education is an important symbol of ego value in our culture, the undervalued role of parent gains in prestige when it is approached by the educational route.

Individual Goals and Aspirations

Education for parenthood should help the mature individual to derive the utmost satisfaction from the experience and to share that satisfaction with others in the family. It should help the personality to mature in proportion to the complex responsibilities of parenthood. For the unborn child, it should prepare a suitable home.

Education for parents should emphasize the primacy of the home since the disruption of family life is at the root of much unhappiness. It should encourage a broad conception of the family unit to provide the child with opportunities for effective relationships and for learning to live with others. It should provide learning of permanent value so that parents continue to build for happy, healthful living long after they have forgotton the details learned in classes for parenthood.

To be effective, health education must be acceptable to people. It is important therefore to help the individuals in the group work out their own methods of achieving what they desire. Although a core of pertinent information should be given, it is not desirable to insist on a particular pattern of performance or care. Effective education keeps in mind that individuals and groups are unique in goals, aspirations, and working methods.

By keeping the class small and having it meet over a fairly long period of time, it is possible to practice permissiveness, both in the teaching pattern and in the conduct of discussion. Young people are accustomed to frank talk, with each other and their friends. They are most receptive when the classroom discussion is at this level of freedom. As they become acquainted, the discussion grows in freedom. This spontaneous talk provides the teacher with the key to unexpressed and unformulated feelings.

Today's parents want to know about fertility and infertility, the uses and dangers of anesthesia and analgesia, the pros and cons of natural childbirth and rooming-in, and the psychophysical rationale of breast feeding. Many want movies of an actual birth.

A good educational program gives them the best available information on which to base their choices. The nature of the child, even before birth, is emphasized throughout so that parents are prepared to receive a baby as an individual personality and not merely as their creature, however loved, to be reared in the pattern of their personalities and wishes.

Often parents are far ahead of professional workers in their ideas of what they should learn. In controversial areas, it is wise to explain the difficulties that may prevent full realization of their desires so that they may adjust sensibly when their efforts fall short of complete success.

Whether they like it or not, for example, most women are obliged to have their babies in hospitals. Whether they like it or not, they are usually separated from their husbands during labor and from their babies after birth. If they make a choice between hospital and home based on realistic information, they are usually able to try sensibly to gain the advantages of both and to adjust without trauma if they don't.

Sharing of Attitudes

Naturally, all of the initiative does not rest with the class. A good discussion leader creates interest in what should be learned and brings about coincidence of teaching and learning goals. In an early session on intrauterine development, for example, we explain the baby's dependence on the mother and her food intake for the baby's body-building needs. Then parents are ready to receive the session on nutrition with real interest in the child's welfare as well as their own.

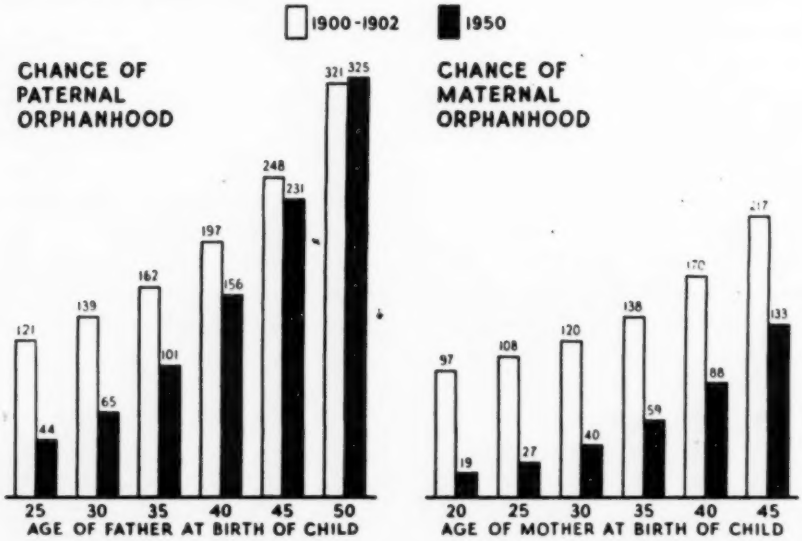
In teaching nutrition, we explain how different food elements serve the body. We do not say "eat this or that" but help each mother and father achieve good nutrition within the framework of familiar food habits and tastes.

Even though deliberate attempts at psychotherapy should be avoided, there can be no doubt that the airing of hopes and fears is beneficial. Throughout pregnancy, for example, there is a shift of interest back and forth between the child and self. Expectant parents often feel guilty and abnormal when their beginning parental attitudes give way to self-concern. They do not always realize that parental feeling is a developing and not a full-born thing. As they understand that a measure of emotional conflict is universal, they grow in self-confidence, and the motivation for learning is strengthened.

No large-scale, continued evaluation of parents' classes has been made, though empirically it seems certain that the shared experience has psychotherapeutic value. Mothers comment on the supportive value of what they learned in class. They write of the pleased surprise and appreciation of their physicians at their performance during labor. Nurses report that women who have had prenatal preparation have an easier delivery and react better psychologically. Mothers and mothers-in-law remark on the emotional growth observed in their sons and daughters.

Education for childbearing does not pretend to eradicate neurotic attitudes or deep-rooted personality traits. It does seek to minimize or prevent new traumatic experiences, to help develop insights conducive to a favorable environment for the coming child, and to aid in the reconstruction of the family in a society that in many of its values and practices tends to rupture family bonds. Education for parenthood which is focused on the family and its individual and collective needs, and which fosters a secure, happy family setting, contributes to the welfare of society as well as of individual mothers, fathers, and children.

Chances in 1,000 that a newborn child will be orphaned before attaining age 18: mortality experience of white population, United States, 1900–1902 and 1950.



Culture and Health Practice

PHR brief

Health, once thought to be governed by the heavens, by implacable fates, or by simple principles of will or virtue, was late to be associated primarily with the elements of earth. And even the earthly view has been troubled by the complex interplay of man with environment and of the individual with society.

The concept that ills have a dominantly physical origin, based in microbes or toxins, was barely established before Claude Bernard, Walter B. Cannon, and Sigmund Freud demonstrated that man is a whole compound of related physical and psychological processes. Such men opened the door to the study of the role that human values, emotional attitudes, and habits play in health. Talcott Parsons searched for roots of psychological patterns and influences within human societies and their social processes. Kardiner spoke of social emotions patterned in social structure. Anthropologists investigated social patterns for clues to their origin.

A preoccupation with evolutionary theory in the 19th century favored the thought that men and their societies "progressed" biologically or culturally, with accompanying assumptions of superiority of advanced races or cultures over the "primitives." Assumptions of racial distinction were discredited by Boas, who linked mental processes firmly with culture and led to a searching analysis of cultural variations.

Since culture itself is a human agency or organization of instrumentalities for adjusting and adapting to nature, it bears upon the shaping of personality and health, both individual and public. Individual reactions are mediated by a whole system of values, attitudes, and behaviors, even with respect to heart disease, arteriosclerosis, or amebic invasion.

In 1940, Dr. Leona Baumgartner suggested that an understanding of the culture of a community would improve the effectiveness of health programs. There are many studies to illustrate how this principle applies in practice. But the culture is complex, requiring insights and knowledge from many contributing disciplines.

The concept of the family as a unit of practice was appraised in 1945 in a report by Dr. H. B. Richardson. Concerted skills of general practitioner, psychiatrist, and nursing and social work personnel were applied for a period of 2 years. It was concluded that the family concept led to better diagnosis and treatment, less pressure on existing clinical facilities, and relatively rapid progress toward sound medical action.

The concept of health and how to obtain it varies with the group, generation, and social class. One may start with existing health practices and behavior, note their function, and their integration into the culture. Such knowledge may become a component of epidemiology and administrative technique for the health officer.

By Marvin K. Opler, Ph.D., department of psychiatry, Cornell University Medical College, and Payne Whitney Psychiatric Clinic, New York Hospital.

An Approach to the Study Of Family Mental Health

PHR brief

In our clinical studies of patients suffering from neuroses and psychosomatic disorders, we have been impressed by the significance of periods of crisis which, in the early stages of an illness, seemed to have determined its direction. In other cases, a period of healthy emotional development appeared to change more or less abruptly to one of unhealthy development at the time of a crisis associated with an upheaval in the social milieu of the patient.

When Erich Lindemann and I joined forces at the Harvard School of Public Health in 1952,

By Gerald Caplan, M.D., D.P.M., associate professor of mental health, Harvard School of Public Health.

we began to develop a framework for communitywide preventive psychiatry based on such studies. Our plans aimed to extend mental health help to families at times of crisis by promoting collaboration between psychiatric workers and the caretaking agents of the community—clergymen, educators, nurses, physicians, and social workers.

Lindemann's investigations of the psychological reactions experienced by the survivors and close relatives of the victims of the Cocoanut Grove fire in Boston had convinced him that a mourning process is accompanied by characteristic emotional changes, that there is a well-defined psychological disturbance in direct reaction to a bereavement, and that an individual who does not succeed in handling the emotional problems involved will be likely to suffer from a consequent psychiatric illness. He also found that a physician, or better still, a clergyman could help a person successfully adapt to a bereavement situation and thus prevent the pathological sequelae of "unsuccessful grieving." His experiences in this venture led him to set up the Wellesley (Mass.) Human Relations Service, where community caretaking techniques are being developed to help individuals adapt in a mentally healthy way to a variety of hazardous life crises.

My findings from my studies in London and Jerusalem on the pathogenic effects of interruption or distortion of mother-child relationships in early childhood had aroused in me the hope that the introduction of mental health concepts into public health practice might improve the emotional environment of young children and lead to a communitywide reduction in the incidence of psychological disorder.

Such considerations have led us to a scientific study of certain common crises which we previously felt were the province of playrights and novelists.

Our Formulations

Our conceptual scheme constantly emphasizes the interplay between the individual and the significant persons in his social milieu.

When we say that someone is mentally healthy or unhealthy, we are rating the equilibrium of his functioning in relationship with others in his environment. We are rating his ability to initiate and maintain satisfying emotional relationships with others, to work productively and fulfill his inner resources, to perceive reality undistorted by fantasies, to adapt to his environment if adaptation is conducive to his welfare, and if it is not, to change his environment in a way that infringes minimally upon the rights of others.

The emotional equilibrium is kept stable by a complicated series of homeostatic mechanisms operating both within his personality and in the social system of his network of close interpersonal relationships. Changes in this equilibrium and in the person's state of mental health may occur during crisis periods.

The essence of a crisis is that a person cannot solve quickly a problem of basic importance by means of his normal range of commonly used problem-solving mechanisms but must employ novel patterns of solution.

Pregnancy, birth, death, and such important role transitions as starting school, a new job, or married life are examples of problems demanding novel solutions and involving the possibility of changes in the preexisting pattern of emotional equilibrium.

An alteration in relationships with those who satisfy emotional needs leads to frustration and eventual impairment of mental health.

In the disorganization precipitated by a crisis, old conflicts become symbolically linked with present problems. The pattern of their previous solution may influence the present adaptation.

A critical factor in determining adaptation to the changed situation is the support mobilized by the traditional helping practices of an individual's culture and by significant helping people in his environment. Help at this time produces long-lasting effects quite out of proportion to the effort expended.

The significant people in a person's environment whose behavior toward him is so important during a crisis are the members of his family, his close associates at work, leaders of the social and religious groups to which he belongs, and the caretaking agents of the community whose role is to help citizens in trouble.

Suggesting a number of avenues of explora-

tion, our formulations about large-scale preventive psychiatry should be tested by building up a body of knowledge concerning the range of adaptive and maladaptive problem-solving methods of individuals in regard to the more common crises, working out ways of integrating this knowledge within the professional framework of caretaking agents in the community, and developing an appropriate scheme for deploying the services of specialized psychiatric personnel in the most economical way to achieve community coverage.

Family Studies

To advance research on certain aspects of our program, we have established a mental health unit in a Boston health center and have built up a collaborative working relationship among psychiatric and public health personnel.

We chose the family unit for study so that we may understand how the family as a group augments or weakens the problem-solving capacities of its individual members.

We chose as our main categories of hazardous circumstances three events in family life with which health workers deal routinely: prematurity, congenital abnormality, and tuberculosis. These categories have the advantage of being notifiable conditions and thus being easy to sample from health department lists.

Our study is still in the pilot stage. So far we have gained entry into 50 families and completed an intensive study of 15. Our families range from middle middle class to the lowest socioeconomic class.

In each case, the public health nurses and physicians continue their traditional services and also help us collect data. As early as possible after the impact of the crisis, they introduce our worker to the family. His first task is to enlist the cooperation of each member in the study and to obtain permission to visit them in their home once a week during the period of the crisis.

After the crisis is over, we carry out an indefinite followup of the study families at progressively longer intervals in order to assess the immediate and long-term results on their mental health.

We have discovered that the discussion of problems is welcome in middle-class families but is often viewed as dangerous by families of low status. Our general approach is to interfere as little as possible with the stressful situation and with the family's method of dealing with it, but after the crisis is over we take on a more therapeutic role in order to strengthen our relationship and obtain information about deeper aspects of the family interactions.

We have found that valid information about crisis reactions can be obtained only while the crisis is in progress. We postpone obtaining background information on the historical development of the family until the pressure of the crisis has passed.

In our studies we have found it profitable to refer to two patterns of family functioning which may be significantly related to eventual mental health changes. These are the "family life style," meaning the reasonably stable pattern of family organization which leads to a range of problem-solving possibilities from which the family, individually or collectively, may choose according to their perception of the demands of the situation, and the "intermediate problem-solving mechanisms," which introduce dynamic forms of adjustment to the crisis.

Although the life styles of certain families may be conducive to mental illness, in many others the life style affords greater or lesser opportunities for mental health. Whether mental illness or mental health develops will be determined by what choices are actually made during crisis periods. The current factors influencing the choices are therefore significant.

During the period when the new solutions are being worked out, certain patterns can be recognized in which the tension is reduced for the family as a group but at the emotional expense of one or more individual members. Emotional exploitation of a family member invests him with a role which infringes upon his needs. In such cases we have observed that the emotional problem was not being adequately dealt with by the group because of poor leadership, disorders of internal communication, or other organizational inefficiencies. Emotional exploitation of an individual reduced group tension by allowing abreaction of anxieties or ventilation of guilt in relation to an object acceptable to the family's value system.

We are beginning to tease out the factors which cause a family member to be singled out for exploitation in this manner as part of the family's response to a crisis, and which consequently endanger that person's future mental health by frustrating his basic emotional needs.

Social Work For the Family

PHR brief

Not many years ago public health workers, physicians, and social workers learned about the family empirically without adequate theoretical formulations on which to base their practice. Today, there is an ever-expanding body of validated theory regarding the family to be tested in application.

Social workers see the family as the cornerstone of society and, therefore, the focus of their attention.

The bulk of present-day social work seeks to sustain families by providing food, clothing, and shelter. Only if such support seeks to enable the individual and the family to contribute in some measure to society is it compatible with the objectives of social work. It is vital for social agencies to be philosophically oriented and practically endowed to provide help that is not on a pennypinching, rockbottom basis.

Professional Cooperation

Characteristically, the social worker operates where there are symptoms of family or social dysfunction. The social worker may know that a patient is well enough to go home and that the hospital needs the bed immediately, but may also know that the family is not in condition to receive the patient.

For example, a boy of 9, a victim of cerebral palsy, was admitted to an institution for handicapped children. Although he was living on an infantile level, he was found to have normal intelligence. During his 2 years at the institution, he learned to feed himself, to use the toilet, and to make his needs known verbally, although his speech improved but little.

The boy's discharge was recommended when it was apparent that he could be treated as an outpatient. However, his mother was not prepared for, in fact, refused to accept, the improvement in his condition. Consequently, the boy regressed at home and probably will require institutional care again.

Hospitals and social agencies must continue to work together in many ways to counteract situations in a family unit which may undo the work of the hospital and physician.

Group and Community Organization Methods

Social workers also use group work and community organization methods which strongly influence family health. The focus of such work is on larger social units, and provides recreational, creative, and citizenship outlets to promote the "pursuit of happiness."

Group interaction, peer relationships, and experience with authority and group leaders tend to produce changes in individual behavior which can be carried over from the immediate group, and the change is subsequently felt in family life.

I wish that public health workers had made more use of community organization skills during recent years in view of some of the roadblocks set up in segments of the community to the advances of medical knowledge. Their success in expediting therapy and release of tuberculosis patients, for example, had striking effects in the patients' families observed by social workers. There was an exacerbation of the anxieties and fears usually aroused by the return of a tuberculosis patient and an apparent prolongation of the period of readjustment.

The family accurately mirrors the community's stereotypes about the nature of contagion,

By Virginia Bellsmith, M.S., professor of social work, New York School of Social Work, Columbia University, New York City.

reinfection, and disability in tuberculosis. Much more than the dissemination of educational material has to be provided if discharged patients are to be accepted by the community. Community social planning is needed. Unless community resources are realigned and augmented, patients can be isolated and housebound.

The planned addition of social workers, with particular community organization skills, to the conventional health and welfare team might significantly alter community attitudes about tuberculosis and its victims and also modify community planning.

Similarly, the use of tranquilizers in mental illness and the mass application of poliomyelitis vaccines are other technological medical advances which require community cooperation for maximum acceptance.

Social Phenomenon

Although in the last 10 years, social workers have attempted to examine systematically concepts and formulations of social work, none of the completed studies have given attention to a phenomenon which social workers have noted in their records for many years, that some adults who make mature, healthy familial and social adjustments grew up in families characterized by gross pathology.

The fact that such growth occurs is variously ascribed to innate strengths in the individual, to hidden assets which counterbalanced deprivation and distortion in the family, or to the fact that we do not yet know enough about the relative significance of traumatizing familial experience in children at different stages of development.

More study of family processes would certainly add to our understanding of cause and effect in personality development. But an examination of the histories of such adults leads me to the belief that a systematic exploration of the importance of consistency and continuity of pattern in such families may provide new understanding about the basis on which healthy personalities and strong egos are built.

PHS Staff Announcements

Dr. Robert J. Anderson has been named chief of the Public Health Service's Communicable Disease Center, in Atlanta. He replaces Dr. Theodore J. Bauer, who has been appointed deputy chief of the Bureau of State Services in the Washington headquarters.

As assistant chief of the Division of Special Health Services in Washington for the past 2 years, Dr. Anderson has directed operational research in tuberculosis, chronic diseases, venereal disease, occupational health, and heart disease control activities.

Following his first service assignment in 1940 as health officer in Newton and Texas Counties, Mo., he entered tuberculosis control work and served in Philadelphia and San Antonio as tuberculosis control officer and later with the California State Health Department. He became chief of the Tuberculosis Control Division of the Service in Washington in 1948.

Dr. A. L. Chapman has been appointed chief of the Division of Special Health Services, replacing Dr. Seward E. Miller, who has been given leave of absence to accept a teaching and research position at the University of Michigan. Dr. Chapman has been medical director of the regional office of the Department of Health, Education, and Welfare in New York City.

Dr. Richard F. Boyd, now medical director in the San Francisco regional office, will move to New York City, replacing Dr. Chapman. Dr. Charles F. Blankenship, now medical director of the Kansas City regional office, will move to San Francisco, replacing Dr. Boyd.

Dr. Lewis H. Hoyle, formerly regional health services consultant at the Kansas City office, replaces Dr. Blankenship as medical director of the office.

Public Health Service Announces New Program For Accident Prevention

THE NEW Accident Prevention Program of the Public Health Service, created July 1, 1956, is located in the Division of Special Health Services, Bureau of State Services. The program is directed by James L. Goddard, M.D. Chief of Program Services is Eugene L. Lehr, a sanitary engineer; chief nursing consultant is Jean F. Williams; and Albert P. Iskrant, a statistician, is chief of Operational Research.

Designed to serve State and local health departments through research, consultation, training, and information, the new program will devote much of the current year to planning in preparation for a considerably expanded operation in fiscal year 1958. In addition to its own staff, the program will use the services of personnel assigned by other interested agencies in the Department of Health, Education, and Welfare. A Departmental Advisory Accident Prevention Committee will help coordinate Departmental activities in the field.

Broadening the scope of the former home accident prevention program in the Bureau of State Services, the new program will, through use of the epidemiological approach, concern itself with the basic factors in accident causation and prevention and will enlist the competencies of all the disciplines in public health. The program will also assume responsibility for the former interests and activities of the Division of Sanitary Engineering Services in the hygiene of housing. Special attention will be directed toward developing guidelines and standards for incorporating basic safety and hygienic features into housing structures, including homes for special occupancy.

The accident category constituted the fourth leading cause of death in this country in 1955, and was actually the first cause of death for the age group 1–34 years. More than 90,000 persons died from accidents in 1955. More than 9,000,000 injuries are estimated to occur each year, causing more than 300,000 permanent impairments.

Since accidents are the result of forces from three sources—the host, the agent, and the environment—the public health procedure of epidemiological analysis, determination of causes, development of preventive measures, and evaluation may be applied in studies for preventing them.

Specialists from every field, including that of human behavior, can be used in the studies of the interrelationship of the forces and multiple causes that lead to accidental injury or death.

A 7-point work program has been set up as follows:

1. Collection and analysis of data.
2. Training (inservice, assignment, and formal).
3. Educational and informational services.
4. Experimental studies and epidemiological investigations.
5. Program demonstrations.
6. Consultation to official and voluntary agencies.
7. Aid to health departments in evaluating and setting up statistical procedures.

Other Departmental agencies cooperating with the new Accident Prevention Program are the Children's Bureau, Food and Drug Administration, Office of Education, and Office of Vocational Rehabilitation. Within the Public Health Service, the Bureau of Medical Services, the National Institutes of Health, the Division of Public Health Methods, and the National Office of Vital Statistics are all active in the work of the program.

Progress in Reporting Mental Hospital Statistics

Sixth Annual Conference of Mental Hospital Statisticians, Topeka, Kansas, April 26–28, 1956

THE STATISTICAL problems created by the widespread use of the tranquilizing drugs, comparisons of results of cohort studies, and measurement of degree of mental illness were major topics at the Sixth Annual Conference of Mental Hospital Statisticians. The conference, held at Topeka, Kans., April 26–28, 1956, was sponsored by the National Institute of Mental Health, National Institutes of Health, Public Health Service.

Delegates from the member States of the Model Reporting Area for Mental Hospital Statistics attended (see box inset). Washington was admitted as the 18th member State at this conference. In addition, unofficial observers from Massachusetts, North Dakota, and South Carolina, St. Elizabeths Hospital, Washington, D. C., and the Veterans Administration were present.

The Model Reporting Area for Mental Hospital Statistics was established in 1951 by mental hospital administrators and statisticians from 11 States. The organization's primary objective is to develop uniform procedures and definitions so that meaningful comparisons of mental hospital data among member States can be made. To meet the minimum requirements for admission a State (*a*) must have a central statistical system to provide reporting from all of its State hospitals, (*b*) must have a professional statistician in charge of the statistical system, and (*c*) must agree to the definitions adopted by the Model Reporting Area and produce annually a minimum number of tabulations agreed to by the area States.

Dr. Morton Kramer, chief, Biometrics Branch, National Institute of Mental Health, opened the meeting by outlining some of the problems facing mental hospital statisticians. Among these, he mentioned the constant demand upon the statistician to justify current expenditures or to show the need for additional funds in view of the large mental hospital appropriations. He also discussed the importance of obtaining adequate data on the effect the increasing use of tranquilizing drugs is having on the Nation's mental hospital systems, and the need for controlled studies to test the effectiveness of these drugs.

Studies on Tranquilizing Drugs

Five delegates indicated that reporting procedures had been developed in their State mental hospitals to determine the number of patients placed on drugs, the number remaining on drugs, and the number from whom the drugs had been withdrawn. These reporting systems are expected to provide the foundation data for future studies of the effectiveness of the drugs. Several delegates reported on current drug studies and those being planned, none of which,

Prepared by the Current Reports Section, Biometrics Branch, National Institute of Mental Health, National Institutes of Health, Public Health Service.

however, involved the use of patients receiving placebos as controls.

Two basic difficulties for the statistician in his role in the studies of the drugs were raised: (1) All too often the statistician is called in to assist in a study after it has already been set up; and (2) frequently, the need for evaluation of such a program is not realized until long after the program has been in operation. In each the statistician is placed in a difficult position. He is often faced with the task of analyzing data obtained with inadequate experimental designs such as lack of control groups, or he may need information which is no longer possible to collect.

Recommendation of Rating Scales

The Committee on Psychiatric Impairment, appointed at the 1955 Conference of Mental Hospital Statisticians, reported on its recommendations concerning the development of scales to quantify the degree of mental illness.

A major difficulty in interpreting release rates from mental hospitals (that is, the proportion of first admissions who are released within a given interval following admission) is that such rates may be influenced by the severity of the patient's illness. Two hospitals having vastly different crude release rates may have identical severity-specific release rates. Thus, observed differences in release rates among all first admissions can be caused solely by a difference in distribution of types of risks entering the two hospitals. It is important, therefore, to obtain some measure of the severity of illness in patients at the time they enter the mental hospitals and at intervals after admission in order to permit meaningful interpretation of release rates.

The committee recognized this need, particularly for purposes of comparing hospitals or hospital systems. It recommended that the National Institute of Mental Health, through consultation with appropriate professional groups, such as the American Psychiatric Association and the American Psychological Association, evolve rating scales, that the States make trial application of such scales in measuring severity of psychiatric disorders, and that the National Institute of Mental Health provide consultation services and material aid to States in the trial use of these rating scales.

The committee also emphasized that the rating of patients be made at least at time of admission and release and at such other intervals as deemed advisable. The scales to be used should be reliable, valid, sensitive, simple of application, and useful statistically. These characteristics are defined as follows:

Reliability—the degree of uniformity with which severity can be measured by different observers.

Validity—the ability of the scale to give results consistent with generally accepted clinical judgments of severity.

Sensitivity—the scale should be a sensitive measure of change in degree of severity.

Simplicity of application—the scale should be easy to use with professional guidance.

Statistical usefulness—the scale should be amenable to statistical classification and analysis.

The committee recognized that other patient characteristics and environmental factors were associated with psychiatric impairment. It was further recommended that attention be directed to the relationship between somatic impairments, household and community factors, and the admission of patients to and their release from mental hospitals. The report of the Committee on Psychiatric Impairment was approved and accepted by the conference.

Cohort Studies

At the 1955 conference, the Cohort Study Committee recommended that members of the Model Reporting Area conduct cohort studies of

Model Reporting Area States

Representatives from the following States are members of the Model Reporting Area for Mental Hospital Statistics.

Arkansas	Michigan	Oklahoma
California	Minnesota	Pennsylvania
Illinois	Nebraska	Texas
Indiana	New Jersey	Virginia
Kansas	New York	Wisconsin
Louisiana	Ohio	Washington

first admissions to State mental hospitals. These studies were to include all first admissions during a period of 3 months or more and were to follow these patients through their hospital experience for 1 year or until death or the first significant release, in order to determine for specified intervals of time, the proportion of first admissions released alive or remaining or dying in the hospital.

During the year, 10 States performed such studies. They reported the gross results at the conference. The percentage of patients released alive within 1 year following admission ranged from 50 to 90.

More detailed comparisons were not possible because the categories used by the various States were not comparable. For example, different age groupings were used by various States and some had further refinements, such as by sex and diagnosis, while others did not.

In view of these difficulties a new Cohort Study Committee, consisting of a statistician and clinician from each of 5 States, was appointed to review the cohort data and the methods of analysis used by the 10 States mentioned above. Each State will be asked to submit cohort data in a uniform manner to allow meaningful comparisons.

The committee will review these studies and meet to consider possible interpretations of interstate comparisons, taking into account as many known factors as possible. The committee will then report to the next conference its recommended interpretations of these studies and, perhaps, suggest further refinements to yield more meaningful analyses.

Uniform Financial Data

The need for uniform financial data was emphasized in a discussion of costs per patient. States are continually comparing their per patient maintenance expenditures with those of other States in order to demonstrate to legislators and the public the need for increased expenditures. It was pointed out, however, that such comparisons of expenditure data are often not valid. Some of these variations which cause noncomparability were noted in (*a*) policy with respect to inclusion or noninclusion of building and improvement expenditures in maintenance costs, (*b*) the effect of climate on fuel and utility costs, (*c*) and the effect of institutional farm operations on food costs.

To circumvent some of these problems in comparisons of expenditure data, it was proposed by one of the States that total man-hours for treatment of patients be classified according to personnel categories such as physicians, nurses, social workers, attendants, and so forth. Under this proposal salaries of these employees would be related to the cost of living index for that region. Thus, per patient expenditures for salaries would be computed and adjusted according to the prevailing cost of living index. Interstate differences in salary levels for a given employee classification, after adjustment for regional differences in cost of living, might indirectly reflect differences in the skill, training, and general quality of such personnel. No specific action was taken on this proposal by the conference.

This problem of per patient cost has assumed sufficient importance to be of major concern to the Council of State Governments. The council, meeting with budget representatives of various States to consider these problems, has made specific recommendations. One called for the Council of State Governments to obtain the definition of "capital outlay" as used by the Bureau of the Census and determine whether it should be modified for mental health purposes. Another suggested that the States compute two sets of maintenance cost figures if they have psychopathic hospitals, one set to include and the other to exclude the maintenance figures for psychopathic hospitals.

The conference appointed a committee, consisting of statisticians from five States, to meet with comparable committees of the Council of State Governments to develop standards for determining the composition of maintenance expenditures. The committee is expected to report its progress at the next conference.

Other Problems

Considerable concern was expressed by some regarding the present nomenclature for mental defectives. A draft of the nomenclature which is an extension of the standard nomenclature was presented by one of the States. This revi-

sion is being applied in that State on a trial basis only. The conference agreed that this is an area requiring further study. It was suggested that States, as they attempt to solve difficulties in nomenclature, keep all the other States informed.

Monthly reporting of a few items concerning movement of mental hospital patients was suggested by one of the States. The objective of such reporting would be to provide simple data for studying current trends in mental hospital admissions, separations, and resident patient populations. It was proposed that a draft of a form for such reporting be prepared and submitted to the National Institute of Mental Health for circulation to the Model Reporting Area States for consideration.

Regional Meetings

The interest generated by these annual conferences has brought about the spontaneous inauguration of regional meetings for mental hospital statisticians from neighboring States. Mutual problems, with special emphasis on interstate comparisons of mental hospital data, were considered. Since most States are interested in comparing data with neighboring States rather than with States far removed geographically, these meetings were felt to have been particularly helpful. Two such meetings were held in October 1955—representatives from 8 eastern States met at Princeton, N. J., and representatives from 7 midwestern States met at Chicago, Ill.

A questionnaire, requesting basic mental hospital data on a current basis, was developed and circulated by the midwestern group. The results were compiled, and a brief report on these comparative data was distributed. This report was found very useful by some of the States for presentation of material to their legislatures.

Home Safety Inventory

State health departments in 32 of 48 States participating are headquarters for the 1956 Home Safety Inventory sponsored by the National Safety Council. Public health agencies are represented in State safety councils serving as inventory centers in the 16 other States.

The basic purpose of the inventory is to help participating agencies let one another know what each is doing to prevent home accidents.

Local health departments will receive inventory forms in December from the State inventory centers. The value of the inventory will depend on how effectively local health departments complete and transmit the forms and report home safety activities of the past year. The information will be analyzed by punchcard devices. Duplicates of the completed forms will be given each participating State health department.

California's Experience in Training Public Health Physicians

By GEORGE T. PALMER, Dr.P.H., and MALCOLM H. MERRILL, M.D., M.P.H.

IT IS a well-accepted principle today that people entering the field of public health should have specialized training. Sedgwick at the Massachusetts Institute of Technology, Vaughan at the University of Michigan, and Abbott at the University of Pennsylvania were pioneers in establishing teaching centers for this purpose as far back as 1890.

Sedgwick's early work was focused principally on the field of microbiology and sanitary science. At that time and, in fact, for many years thereafter, there was doubt in the minds of some as to whether the medically educated worker really needed additional training in public health practice. Gradually, however, it became evident that the scope of a medical health officer's work went well beyond the field of medicine. Knowledge was also required in the fields of engineering, environmental sanitation, vector control, health education, social problems, community leadership, public administration, and laboratory sciences as related to public health as well as other fields.

In order to meet the growing need, schools of public health grew in number and in the scope of instruction offered. Through the years it has become increasingly evident that so far as medical health officers' training is concerned the limiting factor has been the provision of candidates for training. Recruiting of physicians was materially facilitated, though not solved, with the provision of Federal funds for scholarships. These funds became available in California in 1936. The following report summarizes the experience in the training of physicians in California since that time.

Dr. Palmer is consultant in public health training and administration and Dr. Merrill is director of the California State Department of Public Health.

Background of Study

During the period from September 1936 through June 1954, 86 physicians were granted scholarships by the California State Department of Public Health for the 8 or 9 months' course in a school of public health leading to the degree of master of public health. In a very few instances, field training in a local health department was provided for an extra period of 3 months. And in a few instances the scholarship was granted after the beginning of the term and thus did not cover the full period of 9 months.

Training was carried on for the 6 years 1936 through 1941, and then was discontinued during the war years of 1942 through 1945 because of lack of candidates. The scholarship program was renewed in 1946 and has continued without interruption to date. However, no candidates were available for the academic year 1952–53. Thus, this review represents 13 training years.

Omitted from the tabulations that follow are 12 physicians, the 6 who completed training in June 1955 and another 6 who concluded training in June 1956. All of these were promptly placed in local health departments in California.

Table 1. Years served in public health or related field by physicians whose training was sponsored by the California State Department of Public Health, September 1936–June 1954

Number of trainees, field, and length of service	In California June 1954	Have been in California but not present June 1954	Never in California	Total	Percentage distribution of total possible years of service less death years
Number of trainees	49	34	3	86	
Government service years:					
In California	432	174	0	606	68
Other States	3	31	25	59	7
Foreign service	6	8	5	19	2
Military service	20	36	0	56	6
Total government service	461	249	30	740	83
Nongovernment service years:					
Private practice	4	126	0	130	15
Other fields	1	18	0	19	2
Length of service:					
Maximum possible service years	466	434	30	930	
Years lost through death	0	41	0	41	
Maximum possible years less death years	466	393	30	889	
Maximum length of service in California per trainee	18	15		[a]	
Minimum length of service in California per trainee	1	1			
Average years per trainee:					
In California	8.8	5.1			
In total government service	9.4	7.3	10.0	8.6	

The gathering of the basic data has been difficult and time consuming owing to the inadequacy of complete detailed records for the period prior to 1947. We drew on the knowledge of workers long with the State health department and made extensive inquiries of trainees through correspondence. However, accuracy in all particulars cannot be assured. In assembling costs of scholarships, we used the amount prevailing at the particular period when the specific individual amounts were not definitely at hand. The figures used, we believe, are a fair estimate.

Services After Training

A study was made of the subsequent history of employment of the 86 physicians who received training under the program. Special attention was given to determining the number of years after training that each physician continued in full-time public health work, both in California and elsewhere (table 1).

Still in public health or related public health services in California are 49 of the 86 trainees. The term "related" refers to employment other than in health departments, such as teaching in schools of public health or universities or work in various voluntary health agencies or public health associations.

Since receiving training, some of the 49 physicians who were engaged in public health work in California in 1954 have been in health service for one or more years in other areas of the country or in foreign or military service or in private practice.

All but 3 of the 86 have at some time since training spent one or more years in public health or related service in California. There has been an understanding between the scholarship recipient and the State health department that upon completion of training the trainee would accept a position in a California health department and remain in this type of employment for a minimum period of 2 years. The three who have not done so have given justifiable reasons, such as unexpected family circumstances, illness, or compelling calls to foreign service. In one of these instances, the entire amount of the scholarship was repaid to the State.

In addition to the 49 employed in California in 1954 and the 3 mentioned above, 34 trainees who were employed elsewhere in 1954 or who

had died (4 in number) had previously spent a total of 174 years in California service.

Altogether, the 86 trainees have spent 606 years in health service in California, 59 years in health service in other areas of the country, 19 years in foreign service, 56 years in military service, 130 years in private practice, and 19 years in other fields of work.

The total possible years of service (18 years per person for those finishing their training in 1937, 17 years for those finishing in 1938, and so on) is 930. However, 41 years must be deducted for years lost through premature death, thus converting this figure to 889 years.

The 606 service years spent in public health or work related to public health in California represent 68 percent of the 889 possible years. However, if to the 606 years are added the service in other States, foreign, and military service, 740, or 83 percent, of the possible 889 years were spent in government service.

Of the 15 percent of total possible years spent in private practice, it may be said that, although not spent in strictly public health service, undoubtedly there were substantial and worthwhile gains in an understanding cooperation with public health services stemming from the active years spent in this field.

Of the 18 trainees in private practice in 1954, 16 received their public health training prior to 1942. Only two trainees in the training period from 1946 on were in private practice in 1954.

Cost of Training

The average cost of a scholarship for the 86 physicians during the 13 years of the program was $2,910 per person (table 2). Excluded from this sum are operating and administrative costs. The largest item was for stipends, or living expenses, which amounted to about $222,700. The approximate total for tuition was $17,300 and for travel, $10,000. The total is thus about $250,000. For this sum, the taxpayers have already received 740 man-years of professional medical public health service. This length of service represents an average cost per trainee of approximately $338 per year thus far. The figure will decrease, of course, as the years of service increase.

The financial support of the training program for physicians, as well as for other professional personnel not here indicated, has come from Federal funds throughout the entire period with the addition of State funds for the 2 years 1948–49 and 1949–50.

The cost of scholarships have varied considerably over the years. This has been due to a number of changing circumstances, including changes in amount of scholarship allowance reflecting economic changes; the location of the training school, with higher travel and tuition costs for eastern schools; and the change in policies in later years whereby costs in eastern schools were limited to the equivalent of the California school.

The 86 physicians received their training in 8 universities as follows:

California	46	Michigan	4
Harvard	17	Minnesota	2
Johns Hopkins	10	Columbia	1
Yale	5	Vanderbilt	1

It is of interest to note the wide participation of schools of public health throughout the coun-

Table 2. Scholarship costs for physician training in public health

School years	Number in group attending school			Approximate average cost per trainee [1]			
	In California	Outside of California	Total	Stipend	Tuition	Travel	Total
1936–38	21	0	21	$1,770	$55	0	$1,825
1939–41	1	26	27	1,860	330	$230	2,420
1946–50	18	13	31	3,630	215	125	3,970
1951–53	6	1	7	3,230	65	5	3,300
Total	46	40	86				

[1] Average for entire group, $2,910.

try in contributing to the education of California scholarship students.

Discussion

It is believed that the money invested by government in the training of public health physicians in California has been a most valuable investment. While only 68 percent of the 889 possible years of service were spent in public health in California, it is significant that 83 percent of the possible years were spent in government service, either within or outside continental United States. Since the funds were derived primarily from a national source, it is not unreasonable to include service in the general public health field as representing returns on the investment. Taking this into consideration, the average cost to government per year of service of the medical officers covered in this study has been approximately $338 for the 740 man-years to date. When it is considered that in the California public health situation physicians thus trained are for the most part responsible for the administration of State and local public health programs involving the expenditure, at present, of between $40 and $50 million annually, the true significance of the government's investment in training is apparent.

Most of the physicians leaving the public health field were trained prior to 1946. This loss occurred during the unsettled conditions of World War II with the resulting intensification of competitive bidding for the services of these physicians. Since the 1946 period, there has been a distinct change in the status of the public health profession, the development of the Specialty Certification Board in Preventive Medicine, and more attention on the part of the public to provision of better salaries for career public health physicians. The stabilization of public activities has contributed to making a career in public health more attractive as a continuing profession for physicians once they are recruited into the field.

Recruitment, however, is still a difficult problem. The limited number of available scholarships is a vital restriction. In California, for example, with due regard for the training of other professional personnel, there are but six scholarships per year currently available for physicians. It is estimated that at least 10 physicians will need to be trained annually in order to take care of replacements and expanding public health activities in the State.

It is becoming increasingly evident that the only way sufficient physicians can be recruited to the public health profession will be through the provision of a planned program of training that will carry them through the academic year of postgraduate education in public health plus 1 year of residency in an approved health department. With this background they will find employment opportunities that will add 1 year of supervised field experience in public health and 3 years of public health practice. After completing these 6 years of training and experience in preventive medicine and public health, physicians will be eligible for certification by the American Board of Preventive Medicine.

Summary

1. Since 1936, 86 physicians have been granted scholarships by the California State Department of Public Health for academic training in public health.

2. Of these 86 physicians, 49 are still engaged in full-time public health or related public health work in California, and 34 others have been at some time in public health work or related service in California.

3. Of the 889 possible years since completing training, the 86 trainees have devoted 740 man-years, or 83 percent, of the possible years in government service; 606 of these service years have been spent in public health or related work in California.

4. The total cost for training the 86 physicians has been $250,000. If spread over the subsequeat years of service in the public health field until June 1954, this amount represents a cost of approximately $338 per year of service.

5. Eight different schools of public health were utilized in the training of these candidates.

6. It is concluded that this has been a sound investment on the part of government.

7. The need for further extension of this type of training program is indicated.

Etiology of 1954–55 Poliomyelitis Epidemic in Puerto Rico

By DAVID H. NAIMARK, M.D., and NANCY G. ROGERS, B.A.

DURING the latter part of 1954, paralytic poliomyelitis appeared in epidemic form on the island of Puerto Rico. This epidemic became one of the largest outbreaks of poliomyelitis in the recorded history of the island with some 500 cases reported from November 1954 through June 1955.

At the request of the Secretary of Health, Commonwealth of Puerto Rico, plans were made early in December 1954 for viral studies on a representative group of pediatric patients. The laboratory data obtained from this study during the height of the epidemic supplements a preliminary epidemiological report (*1*).

Methods

Cases of paralytic poliomyelitis admitted to the pediatric service of Bayamon District Hospital in Puerto Rico relatively soon after onset of their disease were chosen for study. The hospital staff selected 16 patients, ranging in age from 1½ months to 7 years, collected the appropriate specimens, and prepared case summaries. Materials for collection of specimens were supplied by the Tropical Research Medical Laboratory, United States Army, San Juan, Puerto Rico. The responsibility for handling, storing, and shipping specimens fell to this same installation. Diagnostic laboratory studies for poliomyelitis were performed by the Department of Virus Diseases, Walter Reed Army Institute of Research, Walter Reed Army Medical Center, Washington, D. C.

Initial blood samples were drawn shortly after hospital admission, and subsequent specimens were taken on the 14th to 21st days of disease. Throat and rectal swabs were obtained during the first few days of hospitalization. In fatal cases, generous blocks of tissue were taken from several areas of the brain in addition to a portion of the cervical spinal cord.

Blood drawn in Keidal vacuum tubes was stored overnight at 4° C. Serum was then separated from the clot and maintained in the frozen state until used for serodiagnostic procedures. Throat and rectal swabs were individually placed in sterile screw-capped tubes containing 1 milliliter of veal infusion broth. These were promptly frozen and maintained at −70° C. (dry ice) until thawed for tissue culture inoculation. Central nervous system tissues were aseptically removed at time of autopsy, placed in tightly sealed (screw cap) wide-mouth bottles, and also stored at −70° C. Materials thus collected, and accompanying clinical and laboratory summaries, were periodically shipped in dry ice via air express to the

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Walter Reed Army Institute of Research for laboratory study.

Serums were tested for neutralizing antibodies against the three types of poliomyelitis virus by a modification of the tissue culture metabolic inhibition procedure described by Salk and associates (*2*). The test, as performed, contained serial twofold dilutions of the patient's serum, approximately 100 to 300 tissue culture ID_{50} (*3*) of one of three prototype poliomyelitis viruses (Mahoney, type 1; Y–SK–7, type 2; and D–3–83, type 3), and a suspension of trypsin-dispersed monkey kidney epithelial cells (*4*).

For attempted isolation of virus, broth suspensions of throat and rectal swab specimens were first centrifuged at 2,000 r.p.m. for 30 minutes. The supernatant fluids were treated with sufficient penicillin and streptomycin to bring the final concentration to 1,000 units and 1,000 micrograms per milliliter, respectively. After incubation from 30 minutes to 1 hour at room temperature, individual suspensions were inoculated in 0.1 milliliter amounts into each of 2 or 3 tubes containing tissue cultures from monkey kidneys. Blocks of central nervous system (CNS) tissue from the various anatomical areas were pooled, made into a 20 percent suspension with chilled distilled water, and then processed and inoculated as above.

Inoculated tissue culture tubes were observed daily for microscopic evidence of cytopathogenic effect. If no degeneration was seen after 14 to 21 days, one blind passage of cells and fluid was made and these subcultures observed for a similar period of time. When definite signs of specific cellular degeneration occurred, the tissue culture fluid was harvested and inoculated into a "spot neutralization typing test" as described by Melnick and others (*5*). In this procedure, samples of infected "unknown" fluid were mixed separately with poliomyelitis type-specific monkey hyperimmune serums. Following incubation, these mixtures were each inoculated into two tissue culture tubes and incubated at 37° C. for several days. Preliminary identification was accomplished if protection occurred in the tubes containing one monotypic antiserum but not in the tubes containing the other two antiserums or in the control cultures. In each instance, the procedure promptly identified the cytopathogenic isolate as a strain of poliomyelitis virus, and it was unnecessary to perform quantitative neutralization tests.

Specimens from the 16 patients studied were obtained during December 1954 and January 1955. Nine of these patients died while the seven survivors exhibited definite paralytic manifestations. All 16 patients lived within a 10-mile radius of the hospital, but several cities were represented; 7 resided in Toa Baja, 5 in Catano, 3 in Bayamon, and 1 in San Juan.

Results

Virus isolation attempts using central nervous system tissue were successful in 6 of the 9 fatal cases, with recovery of type 1 poliomyelitis virus in each instance (table 1).

Throat and rectal swab materials were avail-

Table 1. Poliomyelitis virus isolations from 9 fatal cases

Patient No.	Patient's age	Results of virus isolation attempts on.		
		CNS	Throat swab	Rectal swab
1	1½ years	Type 1	Negative	Negative.
2	1½ months	Type 1	Negative	Negative.
3	1½ years	Type 1	Negative	Negative.
4	16 months	Type 1		
5	2½ years	Type 1		
6	1 year	Type 1		
7	4½ years	(1)		
8	10 months	Negative		
9	3 years	Negative		

[1] Results unsatisfactory because of bacterial contamination.

NOTE: Leaders (--) indicate swabs were not available.

Table 2. Poliomyelitis studies of 7 surviving (paralytic) cases

Patient No.	Patient's age	Results of virus isolation attempts		Neutralizing antibody titer against type: [1]		
		Throat swab	Rectal swab	1	2	3
10	5 years	Negative	Type 1	64	<4	<4
				128	<4	<4
11	16 months	Type 1	Negative	64	<4	<4
				128	<4	<4
12	1½ years	Negative	Negative	128	<4	<4
				512	<4	<4
13	7 years	Negative	Negative	16	1024	1024
				64	256	256
14	3½ years	Negative	Negative	<4	8	32
				32	<4	32
15 [2]	8 months	Negative	Negative	256	<8	<8
16 [2]	8 months	Negative	Negative	32	<4	<4

[1] Upper row represents tests with acute phase serum; lower row represents convalescent phase serum.
[2] Single serum samples only were available.

able from 3 of the patients who died and from all 7 surviving patients (tables 1 and 2). In only two instances were isolation attempts successful with these specimens; one strain was obtained from rectal swab material and another from a throat swab. Each of the two agents proved to be type 1 poliomyelitis virus (table 2). Although throat and rectal swabs failed to yield virus in the three fatalities, viral recovery was possible when CNS tissue specimens were used.

Paired serums were available for 5 of the 7 paralytic patients (table 2). Serologic tests revealed a significant rise in neutralizing antibody titer (fourfold or greater) in 3 of these instances (patients 12, 13, and 14). Although no significant increase in antibody was shown with the remaining two paired serums (patients 10 and 11), it should be noted that only type 1 antibody was present, and in each case a type 1 virus was recovered from either the rectal or throat swab. Convalescent serums only were obtained from the remaining two paralytic patients. Both were 8-month-old infants and their serums neutralized type 1 but not types 2 or 3 poliomyelitis virus.

Discussion

All 6 of the 9 fatal cases from whom virus was recovered from the CNS died by the third day of hospitalization, which was still within a few days following onset of illness. Two of the three patients from whom isolation attempts were unsuccessful died relatively late in their illness (one on the 21st and the other on the 57th day of disease). The one remaining CNS specimen was considered unsatisfactory for study because of heavy bacterial contamination. In all nine of the fatal cases microscopic examination of brain and cord tissue resulted in a pathological diagnosis of poliomyelitis. (Gross and microscopic pathological examinations were done under the supervision of Dr. Gerardo B. Polanco, Bayamon District Hospital). It is of course not surprising that no virus could be recovered from the two patients dying late in the course of the disease since general experience has shown that virus can rarely be recovered from the CNS after the second week of disease (*6*).

It is of some interest that isolation attempts were successful in only two instances with throat and rectal swab specimens although presumably all such samples were taken from paralytic poliomyelitis patients. One must consider the possibility that the nasopharyngeal secretions contained little or no virus or perhaps neutralizing antibodies when these samples were obtained; yet, no such explanation suffices for the rectal swabs. More plausible explanations are, perhaps, that only small amounts of throat secretions or fecal materials were obtained thus causing virus dilution to be a critical factor (*1*) or viral inactivation

occurred in the tubes of broth under conditions of subsequent handling and shipment (*2*), or both. These observations appear in general agreement with those of Godenne and Riordan in a recent publication (*7*). They noted that throat and rectal swabs were not ideal specimens for routine poliomyelitis virus isolation attempts.

Demonstration of a significant antibody titer rise between paired serum specimens enabled a diagnosis in three surviving patients. The four remaining surviving patients were shown to possess neutralizing antibodies for type 1 virus alone. This assumes additional significance when one considers that each was convalescing from an attack of acute paralytic disease, and furthermore, in two such instances the children were less than 1 year of age.

Summary

Type 1 poliomyelitis virus was isolated from 6 of 9 patients who died and from 2 of 7 survivors studied in the 1945–55 outbreak of acute paralytic disease in Puerto Rico. A diagnostic increase in neutralizing antibody titer for type 1 virus was demonstrated in 3 of the 7 surviving patients, while the remaining 4 possessed antibodies for this type virus alone.

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National Advisory Council on Health Research Facilities

Marion B. Folsom, Secretary of Health, Education, and Welfare, has appointed 12 members to the new National Advisory Council on Health Research Facilities. The council assists the Public Health Service in administering a program of Federal grants for construction of medical research facilities.

The advisory council, established in the new law, includes 8 leading medical, dental, and scientific authorities and 4 members to represent the public. The Surgeon General of the Public Health Service and an official of the National Science Foundation are ex officio members, with the former serving as chairman.

Members of the council are: Dr. George N. Aagaard, Seattle, Wash., professor of medicine and dean of the University of Washington School of Medicine; Eugene N. Beesley, president, Eli Lilly and Co., Indianapolis, Ind.; Dr. Thomas H. Hunter, dean, University of Virginia School of Medicine, Charlottesville; Dr. Carlyle Jacobsen, executive dean for medical education, State University of New York.

Dr. Paul C. Kitchin, professor of dental histology and embryology, Ohio State University School of Dentistry, Columbus; Dr. Oliver H. Lowry, dean, Washington University School of Medicine, St. Louis, Mo.; Dr. Robert A. Moore, vice chancellor, University of Pittsburgh; F. C. Sowell, vice president and general manager, radio station WLAC, Nashville, Tenn.

Dr. John E. W. Sterling, president, Stanford University, Calif.; Dr. Thomas B. Turner, professor of microbiology. School of Hygiene and Public Health, Johns Hopkins University, Baltimore; Dr. James W. Wilson, professor and chairman, department of biology, Brown University, Providence, R. I.; and James Bradshaw Mintener, former Assistant Secretary of Health, Education, and Welfare.

How much of each lot of vaccine must be tested to provide reasonable assurance of its safety? This paper considers some of the statistical issues associated with this question and, in the process, develops the concept of the consistency of a production process.

Some Statistical Aspects of Safety Testing the Salk Poliomyelitis Vaccine

By JEROME CORNFIELD, MAX HALPERIN, Ph.D., and FELIX MOORE

MANY circumstances can influence the safety of any lot of vaccine. They may be conveniently considered as falling into two distinct classes. The first consists of all those circumstances affecting the ability to produce a safe vaccine, the second those affecting the ability to detect an unsafe vaccine. Problems involving the second class of circumstances we shall refer to as problems of safety testing. In practice the safety of the vaccines released for general use will depend on the successful solution of both sets of problems, and it would be hazardous to place reliance for safety exclusively on either one of the two. Nevertheless, in formulating criteria for safety testing, it is useful to inquire into the amount of testing required to assure a high level of safety without making any assumptions about the safety of the production process. This is equivalent to asking whether it is possible to assure a high level of safety by testing alone, even under the most unfavorable production circumstances that one can envisage. While we shall not be able to answer this question definitively, it will be because of the lack of key biological information and not because the problem is analytically insoluble or even necessarily that the solution, given the key information, would require impracticably large amounts of testing.

The authors are all with the National Institutes of Health, Public Health Service. Mr. Cornfield is assistant chief of the Biometrics Branch of the Division of Research Services. Dr. Halperin is chief of the Biometrics Office, Division of Biologics Standards, and Mr. Moore is chief of the Biometrics Research Section of the National Heart Institute. *They presented this paper at the 115th Annual Meeting of the American Statistical Association, held in New York City December 28, 1955.*

Vaccine Preparation

We begin by reviewing briefly those aspects of vaccine preparation and the minimum requirements for safety testing (*1*) which are pertinent to the subsequent discussion. There are three immunologically distinct forms of poliomyelitis virus. An attack by type 1 virus will confer immunity against further infection by that type but not necessarily against infection by type 2 or type 3. Since the vaccine must provide protection against all three types, it must contain antigens for each. A vaccine prepared from a single virus type is referred to as a single-strain vaccine, while a trivalent

vaccine, the form in which the vaccine is actually used, is a combination of equal amounts of three single-strain vaccines.

Each batch of single-strain vaccine is prepared from a virus pool obtained by propagation on cultures of monkey kidney tissue. The pool is filtered and then tested for infectivity. If sufficiently infective for tissue culture, it is ready for the next step, the preparation of vaccine. A pool is considered sufficiently infective if 0.5 cc. is capable of infecting tissue culture after at least a one-millionfold dilution. The amount by which a preparation must be diluted before it loses infectivity is referred to as its titer. There is, in fact, no single dilution point at which infectivity turns abruptly to noninfectivity, and in practice the titer used is that dilution estimated to result in infectivity for 50 percent of the inoculated tissue culture tubes. The amount of virus present in an inoculum capable of infecting 50 percent of the tubes is referred to as one tissue culture infectious dose ($TCID_{50}$).

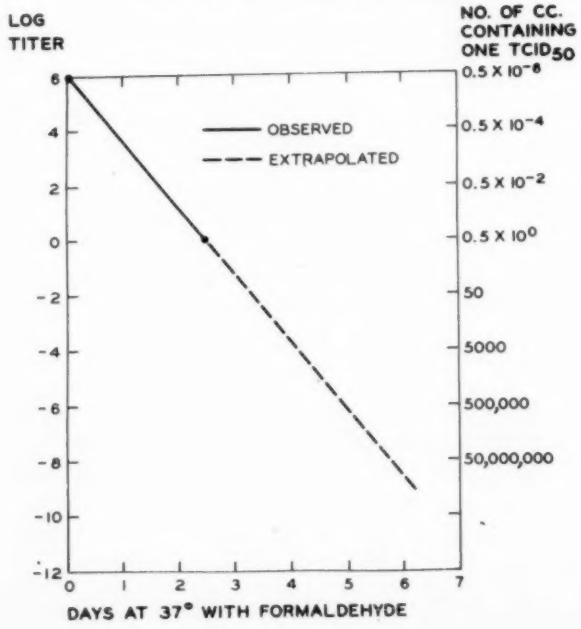
In practice it is more convenient to work with log titers than with titers. We thus say that a virus pool is ready for the next step when its log titer is at least 6. In the next step the pool is exposed to formaldehyde at a temperature of 37° C. and heated for 6 days or more. The preparation loses infectivity continuously but still retains the ability to stimulate antibody production. At intervals during this inactivation process samples are taken and the titer of 0.5 cc. determined. At some point during the process, usually 2 to 3 days, the titer has dropped from at least 1 million to unity, that is, after 2 to 3 days the 0.5 cc. of the preparation, if diluted at all, will infect less than half the tubes into which it is inoculated. Unless one uses larger inoculums or concentrates the preparation, the log titer cannot be easily determined for any period after this time. The curve relating log titer to time heated is referred to as an inactivation curve.

Subsequent to theoretically complete inactivation, tissue culture safety tests are performed. The current tissue culture safety test requires two independent tests of 500 cc. each for each single-strain vaccine, the first test 6 to 9 days after the initiation of inactivation, the second 3 days after the first. In addition, 1,500 cc. of each trivalent vaccine must be tested. The test batch is passed if it produces no tissue changes indicative of the presence of live virus and in addition passes a monkey safety test. This latter test requires that each filling of the final trivalent lot must be tested on at least 5 monkeys, a minimum of 20 being used for each lot. Each monkey receives 2.5 cc. of vaccine. The lot is passed if histological and other studies on the test monkeys "leave no doubt that poliomyelitis infection did not occur"(*1*).

Shape of Inactivation Curve

To point up the difficulties that can arise when exclusive reliance is placed upon the safety of the production process rather than on the adequacy of the safety test, we consider Salk's original concept of factors affecting safety. As elaborated in several publications, the chief guarantee of the safety of the final vaccine was not felt to be the result of a monkey or tissue culture safety test but rather the nature of the inactivation process itself. Thus, it was observed that if log titer was plotted against time of exposure over the observable period, that is, the first 2 or 3 days, that log titer was a linear function of time. Figure 1, which has been adapted from one of the discussions of

Figure 1. Theoretical relationship between log titer and inactivation time.

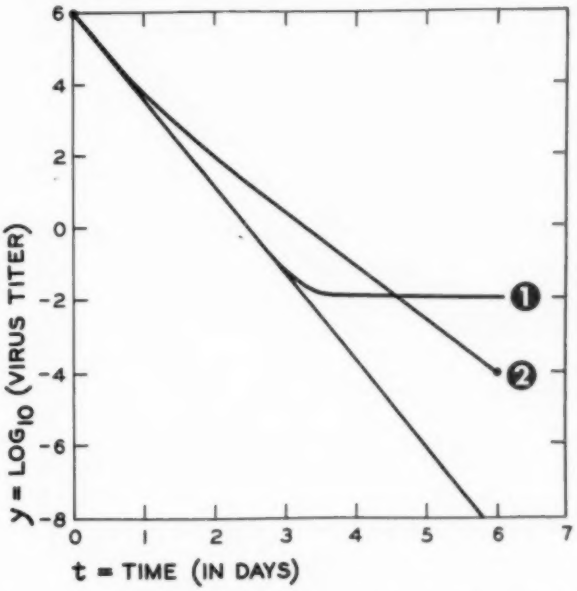


this point subsequently published by Salk (*2*), illustrates this point with a theoretical inactivation curve in which log titer is assumed to drop from an initial value of 6 to 0 in 2½ days. Salk has written (*2*) that the linear nature of this relation "makes possible the prediction, rather precisely, of the time required to render each preparation free of living virus." Thus, in the initial virus pool one tissue culture infectious dose could be found in as small amount as one two-millionths of a cubic centimeter. By 2½ days one would find one $TCID_{50}$ only in every half cubic centimeter, and, by simple extrapolation, by 6 days only one in every 125 million cc. Again quoting from one of Salk's publications (*3*) "[if] the reaction is allowed to proceed for a total period equal to three times the interval required for interception of the base line . . . the margin of safety which guarantees absolute safety has been assured."

The assumption that log titer was a linear function of inactivation time was not an entirely empirical one, simply suggested by inspection of data, but a relationship often found in theoretical chemistry. If the inactivation process is thought of as a chemical reaction analagous to a situation wherein one molecule of virus combines with one molecule of formaldehyde, the latter being present to excess and consequently not limiting the speed of the reaction, then the relationship between log titer and time would indeed be linear, if the system was homogeneous (*4*). Whatever the merits of this formulation from the point of view of inactivation kinetics under controlled laboratory conditions, the occurrence of lots of vaccines containing live virus, even after 9 days of inactivation (*5*), indicated that extrapolation of the inactivation curve was no substitute for safety testing.

It is not hard to see why the extension of results possibly applicable in a homogeneous system to a potentially heterogeneous system might cause difficulty. Thus, figure 2 compares the inactivation curves obtained for two different hypothetical heterogeneous systems with the linear inactivation curve of the preceding figure. In the first curve we have assumed a heterogeneous system with two groups of virus particles, each being inactivated at different rates. One group is assumed to have an initial titer of 10^{6} and a loss of log titer of 2.4 per

Figure 2. Theoretical virus inactivation curves for three different models of the inactivation process.



day, the other an initial titer of 10^{-2}, but it is assumed to have no loss in activity as the reaction proceeds. Such a situation could occur if the bulk of the virus particles were being inactivated as in a monomolecular reaction, but a small fraction, 1/1,000,000, were protected from the action of the formaldehyde by tissue particles. It will be noted that in such a situation the observed inactivation curve would be virtually indistinguishable on any basis from a linear inactivation curve for the first 2½ days, but that thereafter it would level out quite rapidly and, no matter how protracted the time of inactivation, would remain at a level of one $TCID_{50}$ for every 50 cc., a highly infectious level. The shape of the inactivation curve for the observable period would in such a situation provide no guide to the subsequent course of the reaction.

In the second curve we have also assumed two groups of particles being inactivated at different rates. The first group is assumed to have an initial titer of $10^{5.97}$ and to undergo a loss in log titer of 2.4 per day. The second group is assumed to have an initial titer of $10^{4.81}$ and to undergo a daily loss in log titer of 1.47. Some curvature in the observable period will be noted. After 2 days of inactivation this curve is 0.8 of a log titer above the first curve, but it does not

level off as rapidly, eventually crosses it, and at 6 days has one $TCID_{50}$ in every 5,000 cc. Looking only at the observable period, one might place confidence in the eventual noninfectivity of the hypothetical vaccine producing curve 1 and might have serious doubts about the one producing curve 2. Nevertheless, after 6 days of treatment the second vaccine would have only 1/100 the concentration of infectious particles of the first.

These are, of course, only highly oversimplified models of what might happen. The real question is what does happen. To answer this we consider five successive lots of vaccine produced by a single manufacturer. These lots were composed of 104 independently produced and tested single-strain components. Of these, 12 had failed their initial tissue culture test after inactivation was presumably complete and the remainder had passed. We have taken all 12 of the positive components and a haphazardly selected sample of 17 of the 92 negatives. Least squares parabolas have been fitted to each of the 29 inactivation curves. The following tabulation shows for each of the curves the value of the quadratic component at 50 hours for positive and negative lots.

Negative lots		*Positive lots*	
1. 22	0. 66	1. 25	1. 86
1. 82	0. 10	0. 38	0. 22
1. 41	0. 59	0. 85	1. 16
0. 87	0. 63	−1. 59	1. 34
1. 84	0. 28	0. 94	0. 47
−1. 25	0. 57	0. 21	0. 85
0. 07	1. 16		
2. 00	0. 91	Average	0. 66
−0. 11			
Average	0. 75		

NOTE: The quadratic component is the value of ct^2, with $t=50$, where log titer$=a+bt+ct^2$ and t is time in hours.

It will be noted that the value of the quadratic component is less than zero in only three cases, two for negative lots and one for a positive lot. In all other cases the quadratic term is positive, indicating that the best fitting parabola curves up and away from the linear component and that a linear extrapolation will underestimate log titer. The average value of the component at 50 hours, 0.75, involves about the same departure from linearity at that point as does curve 2 of figure 2. The antilog of this value, 5.6, indicates that at 50 hours a difference of more than fivefold in estimated titer had already developed between the best fitting parabola and its linear component.

The fundamental point, however, is that no difference is apparent in the value of the quadratic component for positive and negative lots. Theoretical considerations and actual experience both lead to the same conclusion therefore—that the shape of the inactivation curve up to a certain point provides no necessary indication of its shape thereafter. One can also draw the more general conclusion that no matter how safe a production process is believed to be, common prudence requires safety testing procedures which have high probability of detecting the presence of live virus particles, if by some unforeseen chance the production process permits this to happen.

Size of Test Batch

In many problems of industrial sampling inspection, a decision as to how much to sample is reached by minimizing the monetary loss arising from a combination of testing cost and the costs arising from erroneously rejecting good lots or accepting bad lots of a product (with due regard for the a priori probability that a lot will be bad) (*6*). But in the present problem the loss arising from erroneously accepting an infectious lot is entirely incommensurable with the cost of testing or with the cost of erroneously rejecting good lots. This suggests that the methods of industrial sampling inspection cannot be applied to the present problem without some modification if they can be applied at all.

We may approach a solution by considering first of all an idealized suspension of virus particulates of which we may assume that (*5*):

1. The particulates are randomly and independently dispersed throughout the suspension.

Second, we consider an idealized test system for which we may assume that:

2. One particulate is an effective dose and when introduced into the test system will invariably make its presence known by eliciting some characteristic response.

Since our immediate interest is the logical structure of the problem of safety testing, we

defer to a subsequent section a discussion of the correspondence, if any, between (*a*) the idealized viral suspension and an actual vaccine containing residual live virus and (*b*) the idealized test system and the tissue culture and monkey tests actually used. In this and the following section the "lots" referred to are assumed to have the characteristics of this idealized suspension.

The first assumption is sufficient to assure that if a test volume of v cubic centimeters is taken from a suspension containing m particulates per cubic centimeter (infection level m) the probability that the sample will contain exactly x particulates is given by the general term of the Poisson distribution, namely:

$$e^{-mv}\frac{(mv)^x}{x!} \qquad [1]$$

This is true when the volume of the suspension (V) is large relative to the volume of test sample (v), as we shall assume in what follows. When this assumption cannot be made (*7*), the required probability is the general term of the binomial distribution, namely:

$$\binom{mV}{x}\left(\frac{v}{V}\right)^x\left(1-\frac{v}{V}\right)^{mV-x} \qquad [2]$$

The second assumption says that the probability of detecting growth in the test system is identical with the probability that the test volume contains one or more particulates, namely:

$$\sum_{x=1}^{\infty} e^{-mv}\frac{(mv)^x}{x!}=1-e^{-mv} \qquad [3]$$

Thus, in testing v cc. from a suspension at infection level m the probability of an erroneously negative test is e^{-mv}. By varying v and m it is possible to explore numerically the probabilities of erroneously accepting suspensions at different infection levels and using different sample sizes. For example, if one tests 500 cc. from a suspension containing 5 particulates per 1,000 cc. the probability of a negative result is 0.08, since

$$e^{-(.005)(500)}=.082$$

Thus, 8 percent of all suspensions at this infection level would pass a test using 500 cc.

The minimum requirements imply that 1,500 cc. of each single strain vaccine will be tested on tissue culture and at least 50 cc. more on monkeys. If assumptions 1 and 2, held for both tissue culture and monkey tests, the additional safety assured by the 50 cc. could for the purposes of this calculation be disregarded. In that case the probability of passing a single-strain pool at infection level 5 per 1,000 cc. would be

$$e^{-(.005)(1000)}\times(\text{probability of a negative in the 1,500 cc. in the trivalent pool})$$

If the infection level for the trivalent pool is also assumed to be .005, this gives a final probability of a false negative of $e^{-(.005)(2500)}$.

Thus, the probability of accepting single-strain pools containing 5 virus particulates per 1,000 cc. would be less than 1/100,000 if assumptions 1 and 2 were satisfied. This is the probability given in the White Paper for passing a single-strain vaccine produced at infection level 5 per 1,000 cc. (*5a*).

Consistency

There are a number of questions that can be raised about this formulation. We note first that it appraises a lot solely on the basis of the evidence furnished by that lot and makes no use of prior information on the consistency or inconsistency with which negative lots have been produced in the past. In practice the Public Health Service's Technical Committee on Poliomyelitis Vaccine, which must approve each lot before it is released, has "been influenced as much by the plant record for consistency of performance as by the negative results of tests on the individual lots considered" (*8*). But there has been no precise criterion of what is meant by consistency. This is the question to which we now turn.

We start by borrowing a concept from the literature of quality control and consider the average outgoing quality of lots passing the new safety test. More precisely we ask: What is the probability that a cubic centimeter of a suspension passing the safety test will contain some specified number of particulates, say one or more? Making the same two assumptions as were made earlier we find that no answer to this

question is possible because we do not know the infection level at which any given vaccine is produced. Suppose, for example, that all lots being produced by a manufacturer contain exactly one particulate per liter. Then no matter what the safety test, so long as any lots at all are passed, the outgoing lots will also contain one particulate per liter. In such a case, of course, a considerable proportion of batches submitted would fail the safety test, and it is unlikely that anyone, producer or tester, would feel any great confidence in the safety of the batches that passed. This example suggests that if one wishes to control the probability that an outgoing cubic centimeter contains live virus, one must consider not only the lot being tested but also the past history of testing, that is, the consistency with which safe lots have been produced. It also suggests a general way of proceeding.

Subject to the assumptions made earlier let us initially consider a manufacturer producing a single-strain pool at constant infection level m. Denote the probability that a cubic centimeter contains one or more particulates infectious for the test system by P. Then

$$P=1-e^{-m} \qquad [4]$$

We shall henceforth refer to P as outgoing quality. Denote the probability that a batch produced at this level of infection will pass when v cc. are tested by Y. Then

$$Y = e^{-mv} \qquad [5]$$

and

$$P = 1 - Y^{1/v} \qquad [6]$$

For this simplest situation we thus have a relation between the probability that an outgoing cubic centimeter contains one or more particulates, P, and the proportion of lots, which pass, Y, for constant test level, v. P is a quantity that we wish to keep below some minimum level; the amount tested, v, is subject to our control; and Y, the proportion of lots passed, can be estimated from past experience. As it stands the model is too simple to be realistic, but solely in the interests of understanding its implications let us explore it numerically. Suppose we set P at some low level, say 5/100,000 and consider v=4,500, that is, we consider the entire testing process to consist of a single test of 4,500 cc. of the final trivalent pool. We then have

$$5\times10^{-5}=1-Y^{1/4500}$$

Solving, we obtain Y=80.0.

That is to say, if a manufacturer is producing lots at a constant but unknown level of contamination, and if 4,500 cc. of each batch are tested and 80.0 percent pass, then, given the assumptions previously made, it follows that out of every 100,000 cc. released, 5 would be expected to contain one or more live virus particulates.

If now under this model we wish to assure that the probability of live particulates in a cubic centimeter of passed vaccine never exceeds 5/100,000, we pass a lot if, and only if: (a) the lot under consideration passes a safety test involving 4,500 cc.; and (b) at least 80.0 percent of previously tested lots have passed.

In practice we should, of course, wish to safeguard ourselves against a number of contingencies, perhaps the most important of which is that the level of m fluctuates from time to time. In that case one might wish to use only recent production information in estimating the value of Y for a producer. Suppose, for example, one looked at only the last 10 lots produced. If the probability of a negative were in fact constant and equal to .8, then the probability of passing all 10 is .11, which is rather high and suggests that a run of 10 negatives is not too improbable even for a Y less than .8. The probability of passing 20 out of 20 when Y=.8 is, however, .012, while the probability of failing 1 out of 20 is .058. One might thus regard 20 negatives out of 20 as evidence at approximately the .99 level of confidence that Y was at least equal to .8 and at least 1 positive out of 20 as evidence at this level that Y might be below .8. An amended procedure for providing that the probability of live particulates in a cubic centimeter from passed lots does not exceed 5/100,000 would be to pass a lot if, and only if, it formed part of a run of 20 negative lots. More generally if we denote by n the size of the run of negative lots required, we have

$$n = \frac{\log \alpha}{v \log (1 - P)}$$

where $(1-\alpha)$ is the level of confidence.

Size of negative run (n) required to insure given confidence ($1-\alpha$) that average outgoing infectivity per cubic centimeter is less than P (for selected values of α, P, and test volume, v).

$(1-\alpha)$	$P=1\times10^{-5}$	$P=5\times10^{-5}$	$P=25\times10^{-5}$	$P=50\times10^{-5}$
	$v=1{,}000$			
.95	303	60	12	6
.99	465	92	18	9
.999	698	138	28	14
.9999	930	185	37	18
.99999	1, 162	231	46	23
	$v=5{,}000$			
.95	61	12	2	1
.99	93	18	4	2
.999	140	28	6	3
.9999	186	37	7	4
.99999	233	46	9	5
	$v=10{,}000$			
.95	30	6	1	1
.99	47	9	2	1
.999	70	14	3	1
.9999	93	18	4	2
.99999	116	23	5	2

We show in the table above the values of n for various levels of confidence, sample volumes, and levels of outgoing quality.

The rule derived is in a general way consistent with recent practice in accepting and rejecting lots. In the 1954 field trials, however, its use would have led to the rejection of the two lots whose production was preceded and followed by lots which tested positive. The lots which tested positive were discarded, but the two lots sandwiched in between were used in the field trials, a practice inconsistent with any consistency rule. (A rereading of the slides which led to calling these lots positive has, in the light of the accumulated experience, prompted rediagnosis. All four lots are now believed to have tested negative, according to a personal communication from David Bodian. This finding, of course, should not be construed as justification of the 1954 practice but rather as an explanation of why it did not lead to difficulties.)

Most of the modifications of this model which are required to make it more realistic are straightforward, but involved, and we shall not discuss them. There is one modification of possible interest that we mention here, however. We have justified the rule of estimating Y only from the 20 previously produced lots by considering the possibility that the level, m, fluctuates from lot to lot. The relation between P and Y was obtained on the assumption that it is constant, however. Does the relation between P and Y continue to hold when m is no longer assumed constant from lot to lot?

A perfectly general answer can be supplied. No matter how m fluctuates one can show

$$\overline{P}\leq 1-\overline{Y}^{1/v} \qquad [7]$$

where $\overline{P}$ and $\overline{Y}$ are averages of equations 4 and 5 over the appropriate distributions of m (see inset). The equality between P and Y pre-

Derivation of Equation 7

Define P and Y by equations 4 and 5; let m be the level of infection of a lot, and let v be the cubic centimeters tested of each lot. If now we suppose that m has an arbitrary distribution $F(m)$, we define $\overline{Y}$ by

$$\overline{Y}=\int_0^1 e^{-mv}dF(m) \qquad [8]$$

and $\overline{P}$ by

$$\overline{P}=\frac{\int_0^1(1-e^{-m})e^{-mv}dF(m)}{\int_0^1 e^{-mv}dF(m)}=1-\frac{\int_0^1 e^{-m(v+1)}dF(m)}{\overline{Y}} \qquad [9]$$

From Liapounoff's inequality

$$\int_0^1 e^{-m(v+1)}dF(m)\geq\left[\int_0^1 e^{-mv}dF(m)\right]^{\frac{v+1}{v}} \qquad [10]$$

Substituting from equation 10 in equation 9, equation 7 follows. A somewhat more general result has been obtained by Paul Meier in a study as yet unpublished.

viously used now turns out to be an inequality and, fortunately, in the direction to make it useful. Thus, if 80.0 percent of a long series of lots, 4,500 cc. of each of which are tested, test negative, then the probability that a cubic centimeter of passed material contains one or more particulates is equal to or less than 5/100,000. The assumption that m is constant is consequently the least favorable one for the safety tester, and the procedure suggested is one which protects him against the least favorable a priori distribution of m.

What are the factors that will influence the level at which P, the level of outgoing quality, is set? This is not a statistical question and consequently not one to which we can give an answer. It is, nevertheless, a question to which an answer is required, and it is worth indicating briefly some of the issues involved. First of all, P cannot be set at zero. That is to say, no amount of consistency testing can assure the complete absence of infectivity. The most that can be done is to keep P, the proportion of infected cubic centimeters, below some preassigned level. In selecting a numerical value for P, one must be guided by the consequences of the choice. The first major difficulty is that the consequence of introducing one virus particle into a human host is unknown. That is to say, if P is set at some value say 5/100,000, and the production process is such that five 1-cc. inoculums in every 100,000 released do in fact contain one virus particulate, we are unable to say whether any of the five children receiving the infected inoculums would contract the disease. In the next section we shall consider more closely the relation between exposure to live virus particulates and the subsequent development of disease. Here we shall simply make the overly conservative assumption that all children exposed to one or more live virus particulates invariably develop the disease—that in setting a value of P we are also setting the incidence rate for poliomyelitis.

Now, the average annual incidence of paralytic poliomyelitis is very low. In the average epidemic year of 1954 it was about 50 per 100,000 persons in the age group 5–9 in areas covered by the field trial of the vaccine (*9*). The Francis report indicates that the 1954 field trial vaccines reduced this rate by at least 50 percent, and epidemiological analysis of the 1955 experience leads to much the same conclusion (*10*). Thus, a value of P set at, say 50 percent of 50/100,000 would not be safe enough since such a safety testing procedure could barely assure that passed vaccines would not cause more cases than they prevented.

The Cutter experience is illuminating. Approximately 400,000 children were inoculated with vaccines from 17 different filling lots produced by Cutter Laboratories. There were 61 cases of paralytic poliomyelitis among these children within 50 days of vaccination and an additional 97 among family or community contacts within 65 days. This amounts to an overall paralytic rate of 40 per 100,000 persons, most of which can be attributed to the vaccine. If we insist on setting P at 50 percent of 50/100,000, then the level selected is approximately equal to the average Cutter level of infection. Undeniably this is not safe enough and P must be set well below 25/100,000. How far below 25/100,000 is suggested by the fact that Cutter vaccines were withdrawn from use not after 61 cases but after the first 6 cases out of 400,000 vaccinations.

One might of course argue that it is inappropriate to consider the annual incidence of poliomyelitis and that, in fact, a more appropriate magnitude is the lifetime probability of contracting the disease. This probability is a good deal higher, about 800 per 100,000 persons by age 24 according to a study of children of native white parents in 28 cities (*11*). Since this is 10 to 15 times the annual incidence, one might incline to a value of P well above 25/100,000. There are several problems raised by this issue, however. First of all, if the risk of infection by the vaccine is to be balanced against the lifetime probability of developing the disease, then it is necessary that the vaccine confer lifetime immunity. Whether this is in fact the case is not now known and presumably will not be known for some time (see Salk (*12*), however). Second, and perhaps more fundamental, it is doubtful whether any community would (or should) tolerate safety standards that will permit the release of vaccines that raised the incidence of paralytic poliomyelitis in that year

on the grounds that the increase would be more than counterbalanced by decreases in subsequent years.

It is even more difficult to indicate what factors should be considered in selecting a level of confidence. From a practical point of view, however, the value selected is not as crucial as that of P. Thus, increasing the level of confidence from .99 to .99999 increases the required length of negative runs by about two- and one-half-fold, whereas decreasing P from 5 to 1 per 100,000 increases it by fivefold. In general, the choice requires a compromise between the desire for a high degree of confidence and practical limitations on possible sizes of n.

It is important to realize that, after one has determined a value for outgoing quality, say x/100,000, and a confidence level, $1-\alpha$, it does not necessarily follow that in proportion α of the negative runs x cc. in every 100,000 will in fact contain live virus. What will actually happen depends on the safety of the production process. If the production process is safe, such levels will not occur. The logical structure of safety testing, in short, necessitates fixing a maximally tolerable level of outgoing infectivity, but this level need not necessarily ever be realized.

On the Assumptions Used

The key assumptions of the preceding section are that: (a) a vaccine can be considered as an idealized suspension of randomly and independently dispersed particulates, (b) the tissue culture and monkey tests used can be considered as an idealized test system capable of invariably detecting the presence of a single virus particulate, and (c) a child may be considered maximally sensitive and invariably capable of developing poliomyelitis, even when exposed to a single virus particle.

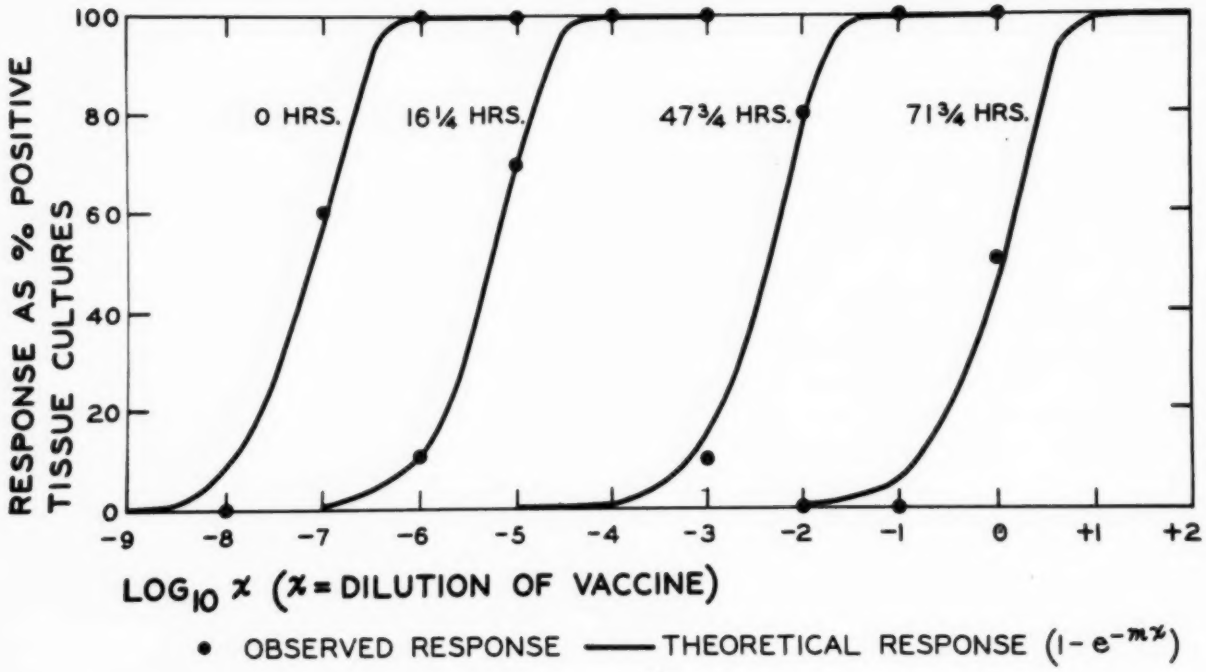
Several bits of evidence suggest that the last assumption is incorrect by several orders of magnitude. First of all, most persons have developed an immunity to the disease by the time they reach adult age even though not more than 1 percent have ever had clinically manifest poliomyelitis. Associated with this is an increased level of neutralizing antibodies (*13*), which suggests that most adults were at some time in life infected by poliomyelitis virus without ever having developed the disease. More direct evidence on this point is provided by a longitudinal study of familial infection with poliomyelitis virus by Fox and associates (*14*). During a 3-year study of 156 households, they noted the development of 240 cases of infection with poliomyelitis virus as indicated either by the recovery of virus from stools or elevated serum antibody levels or both. There was not a single instance of paralytic disease in any of the 240 cases. Extrapolating these results to the community of which the households were considered to be a sample (for which community the incidence of paralytic poliomyelitis was known) they concluded that 1 paralytic case develops for every 710 cases of infection with poliomyelitis virus by the oral route.

Further suggestive evidence on this point has been brought to our attention by Nathanson and Hall. There were 105 cases of poliomyelitis among family contacts of Cutter vaccinated individuals. These may be presumed to have been infected by vaccinated family members. Only 1 of these 105 family members developed a case of the disease. Thus, on this premise, of 105 individuals sufficiently infected to pass the disease on to others 104 did not develop clinical poliomyelitis. The assumption that a child is maximally sensitive is thus a very conservative one. Testing procedures based upon this assumption will possess a considerable margin of safety, at least on this score.

Turning to the first two assumptions, we note that they imply that if one tests v cc. of a vaccine at infection level m, the probability of a positive result is from equation 3, $1-e^{-mv}$.

This relationship between the probability of a positive result and amount tested, often referred to as the one-particle curve, is a well-known relationship in virology. It has been tested on a variety of plant and animal viruses and usually, although not invariably, found to apply (*15*). In principle, its applicability to the present problem could be tested by varying v in a vaccine preparation known to contain incompletely inactivated live virus. In practice, v can be varied only by diluting the vaccine, and the amount of live virus present in the vaccines tested has not been sufficient to give positive responses after dilution. To investigate

Figure 3. Tissue culture response during inactivation.



the question, we have consequently turned to data lying behind the inactivation curves previously discussed. The log titers on these curves are obtained by testing four successive tenfold dilutions. A volume of 0.5 cc. of the diluted suspension is introduced into each of 10 tissue culture bottles at each dilution and the presence or absence of viral growth noted. We show in figure 3 the results of one such run at four different inactivation times. The description of the relation between proportion of positive bottles and dose provided by the one-particle curve appears satisfactory, although a more searching examination would be possible if the spacing between dose levels were not so wide. A very large number of such comparisons is in fact possible, one for each single-strain lot of vaccine produced by each manufacturer. We have not investigated more than a fraction of them, but, for most of those that we have, the agreement between observation and hypothesis shown in the figure is by no means unusual.

Such agreement would appear to validate both the assumptions of an ideal suspension and of an ideal test system. This is too hasty a conclusion, however. Aside from the fact that no data are given for inactivation times beyond the third day, the assumption that one particulate will invariably initiate growth is sufficient but not necessary for the derivation of the one-particle curve. Thus, if we substitute for assumption 2 (p. 1048) the less limiting assumption:

> 2′. The probability that a virus particulate will initiate growth is constant for all tissue culture bottles and equal to p, and this probability does not depend on whether other particulates present have or have not initiated growth,

we also obtain the one-particle curve. Thus, the probability that a test batch of v cc. will contain z particles and that none of these will result in growth is

$$e^{-mv}\frac{(mv)^z}{z!}(1-p)^z \qquad [11]$$

The probability of no growth is simply the sum of such terms over all values of z, and this sum is simply

$$e^{-pmv} \qquad [12]$$

We can estimate the product pm from data such as that given in figure 3, but not p and m separately. In consequence the agreement between observed and theoretical in figure 3 provides no evidence on the numerical value of p and

hence on the choice between assumptions 2 and 2′.

In the literature of virology the parameter m is usually referred to as the number of elementary bodies and the parameter pm as the number of infectious units. The ratio of infectious units to elementary bodies has been determined for a number of virus-host systems. Two lines of evidence suggest that for the poliomyelitis virus its value in tissue culture may be well below unity and that assumption 2′ rather than 2 is the appropriate one. The first is provided by electron microscope photographs of purified poliomyelitis virus preparations. From these it has been estimated that $p=1/30$ to $1/60$ (*16*). The second is provided by the results of intraspinal inoculation with infectious vaccine of monkeys rendered especially sensitive by pretreatment with cortisone. In a number of such experiments the dose required to infect the monkeys has been only a fraction of the dose required for tissue culture. Neither piece of evidence can at present be considered much more than suggestive. The results of the monkey experiments are as yet unpublished and require confirmation, while uncertainty as to the viability of the particles seen in the electron micrograph enjoins caution in interpretation. In the words of Dulbecco and Vogt (*17*) the relation between infectious units and elementary bodies "is still an open problem of highest interest." The mere fact that it is an open question does suggest, however, that a logical structure which is dependent upon the validity of assumption 2 may not be firmly grounded.

The first assumption, that a vaccine may be considered as an idealized suspension of randomly and independently dispersed particulates has also been questioned. Thus, Veldee has argued (*18*) that in the original virus suspension a significant proportion of virus particles are known to be imbedded in gelatinous protein material which cannot be removed by the finest filters. He suggests that formaldehyde may harden this material so that the imbedded virus particles cannot attach to the tissue cell in tissue culture. Growth of the virus in tissue culture is thereby prevented. Once the vaccine has been injected into a living animal, he goes on to suggest, enzymes present in the animal, but not in tissue culture, may free the virus particle of its coating, after which growth may take place. No evidence that would either support or contradict this hypothesis is known to us.

If in the light of this discussion we reexamine the preceding section, it becomes apparent that the three assumptions listed at the beginning of the present section are sufficient but not necessary. The necessary assumptions are less limiting, namely, (*a*) the test system used is at least as sensitive to the presence of live virus as the human subject and (*b*) the probability of a negative response in tissue culture is a decreasing exponential function of test volume. The second assumption is supported by results of the type summarized in figure 3. The first is the crucial one and unfortunately the one about which only indirect evidence is ever likely to be available.

To cast some light on its possible validity, we consider the only evidence now available—the results of a cooperative study, undertaken immediately after the Cutter incident, of 16 of the 17 filling lots of vaccine produced by Cutter Laboratories. All 16 lots were tested in tissue culture, the total amount tested being somewhat less than 6 liters, or considerably less than is called for by present minimum requirements. Nine of the sixteen lots were also tested in 391 normal monkeys and 10 of the 16 in 178 intraspinally inoculated monkeys, which had been pretreated with cortisone. Of the 16 lots tested 6 were associated with an excess incidence of poliomyelitis (*9*). All 6 of these lots gave positive results, and, in addition, 2 of the lots that were not epidemiologically implicated also tested positive, 1 by tissue culture and 1 by cortisone treated monkey. These tests, which are not as extensive as those now called for by the minimum requirements, thus indicate that at least so far as the Cutter lots of the spring of 1955 are concerned the test system now used is as sensitive as and probably more sensitive than the human host. It would, of course, be desirable to have a good deal more information than can be extracted from that experience, but the results as far as they go are in the direction of validating the present testing program. Between the Cutter incident (and after the adoption of the new minimum requirements on May 26) and January 1, 1956, 37,500,000 cc. were released for public use without, so far as is

known, being related to the development of any further cases. This is consistent with the conclusion suggested by the post-Cutter cooperative tests although it is of course hopelessly confounded with simultaneous improvements in the safety of the production process.

Summary

The safety of a vaccine will depend both upon the basic safety of the production process and the ability of safety testing procedures to detect an unsafe vaccine, if one is produced. Exclusive reliance upon the safety of a production process with a good past record, without the second line of defense provided by an adequate safety test, may be hazardous. Salk's early discussions of the nature of the inactivation process are reviewed, and his conclusion that safety was assured by the predictable nature of the inactivation process is critically appraised.

The major statistical problem in safety testing involves a decision as to how much testing is required. The procedures used in industrial quality control to solve this problem are not applicable to vaccine testing because the costs of erroneously rejecting good lots and of erroneously accepting bad ones are entirely incommensurable. An answer is derived instead by making certain statistical assumptions as to the dispersion of live virus in the vaccine, the sensitivity of the test system, and the viral concentration which is infective for man. The question of consistency testing is considered and a general theory derived for deciding how many successive lots of vaccine testing negative are required before a producer can be said to be a consistent producer of safe vaccine. Some of the questions that must be answered to apply this theory are considered. The assumptions on which this theory is based are critically analyzed.

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Recent Studies in Surface Disinfection

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ALTHOUGH many studies on disinfection have appeared in the literature during the past 75 years, significant and unexpected gaps in our knowledge of germicides remain. Efficiency in disinfecting floors, walls, and ceilings is one of the more significant gaps requiring detailed study. Until 1953, little information on the basic aspects of such disinfecting operations was available although Varley and Reddish (*1*) and Klarmann and associates (*2*) presented important but limited data.

For the past few years, the Department of the Navy has been conducting an extensive investigation of the problem at the Industrial Test Laboratory under the cognizance of the Bureau of Ships and Bureau of Medicine and Surgery. Because of the extent of the work, certain portions of this investigation were performed under contract at the Bacteriological Unit, Plant Pest Control Branch, Agricultural Research Service, Department of Agriculture, under the direction of Dr. L. S. Stuart. The salient findings obtained from these investigations to date and the results of certain other pertinent studies recently reported are reviewed in the current report.

When critically examined, disinfection of floors, walls, and ceilings represents a comparatively complex problem because of the many variables encountered in diverse disinfecting operations. Such variables as the composition of the surface, the degrees of soil and microbial contamination, the type of micro-organisms present, the use of a washing procedure before disinfection, the degree of hardness of the water used in preparing the disinfectant dilutions, and many other factors represent a gamut of test conditions to be examined in a study of this nature.

Initially, it was obvious that not all of these conditions could be thoroughly investigated and that some compromise was required. Ultimately, it was decided to limit the study to floor disinfection by simulated use methods incorporating the various conditions described below.

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Principal Test Methods

Two basic procedures for determining antimicrobial activity were developed for most of the work reported here (*3–5*). The first, the "Stuart" procedure, was used to measure the effect of precleaning on subsequent disinfection and consists of successively contaminating, cleaning, and disinfecting a large square of surface material. The pattern of elimination of micro-organisms is followed throughout the simulated precleaning and disinfection. The second, the "Square-Diluent" procedure, consists of contaminating and disinfecting 1-inch squares of surface materials in a manner that simulates actual conditions. This technique was used in all studies in which surfaces were not precleaned before disinfection.

The first technique gives a valid picture of the relative changes in antimicrobial numbers since a swab recovery technique is employed. The second method is of more value when the

absolute numbers of microbial survivors are required. Both techniques are versatile and permit the inclusion of many significant variables in actual disinfecting procedures.

Disinfectant Specificity

Obviously, the most useful disinfectants possess a minimum of antimicrobial specificity. In practical terms, this means that a disinfectant should be effective against a wide spectrum of microbial species when employed at a practical use-dilution. The particular specificities of some types of germicides have been known for some time, for example, the failure of unfortified pine oil formulations to be effective against pyogenic cocci. However, deficiencies in other types became apparent during the study. Table 1 presents representative data to illustrate this point.

On surfaces not precleaned, the quaternary ammonium germicides are effective under certain conditions. Substantial increases in the manufacturers' recommended concentrations of quaternaries are needed to achieve a high degree of bactericidal activity, but the new use-dilutions are not impractical to employ (table 1). However, these germicides are seriously deficient in antifungal activity, and require impractically strong concentrations in most instances.

The particular chlorine product tested was much less effective against pyogenic cocci than against enteric bacilli and dermatophytic fungi (table 1). However, it cannot be stated at this time that chlorine products in general show this extreme specificity under conditions simulating floor disinfection because of the limited number of chlorine products tested. Also, it should be emphasized that such specificity may not be evident when the above or any chlorine product is employed as a sanitizer or water decontaminant; the environmental conditions in these instances, bacterial load, exposure time, physicochemical factors, and the like, are entirely different from those encountered in floor disinfection.

The synthetic phenolic and unfortified cresylic acids and coal tar products show less specificity than the other products. In most instances, the manufacturer's recommended use-dilutions are effective against the three test organisms. This is, perhaps, understandable, since the classical determination of use-dilution by extrapolation of laboratory data, that is, use-dilution in practice = 20 × phenol coefficient obtained in a standard laboratory procedure, has been found to be more applicable to synthetic phenolics and related types than to quaternary ammonium germicides and halogens (*6*). However, discrepancies can readily be demonstrated even with the phenolics (*7*). This entire question of the correlation between phenol coefficient and recommended use-dilution is of sig-

Table 1. Disinfection of a nonporous surface (stainless steel) by various germicides without precleaning

Germicide	Recommended use-dilution	Effective dilutions [1]					
		Without serum			With serum		
		MPA	SS	TI	MPA	SS	TI
Phenolic A	1:250	1:250	1:1500	1:250	1:130	1:250	1:130
Cresylic	1:150	1:150	1:600	1:180	1:150	1:600	1:150
Chlorine	[2] 1:5000	1:310	1:3100	1:4600	<1:310	1:3100	1:4000
Quaternary ammonium	1:2500	1:1000	1:1000	<1:100	1:1000	1:1000	<1:100

[1] Dilutions of formulations (active ingredients only) required to obtain 99.99 percent reduction (bacteria) or 99.9 percent reduction (fungus) in Square-Diluent method. See reference 4 for details.

[2] Based on available chlorine.

MPA = *Micrococcus pyogenes* var. *aureus*; SS = *Salmonella schottmuelleri*; TI = *Trichophyton interdigitale*.

nificance in the concept of disinfection but has been adequately treated elsewhere (*6*, *7*).

Surface Porosity

Although the above generalization on the relative effectiveness of disinfectant types is valid, surface porosity tends to alter the quantitative pattern in certain instances (table 2). For example, certain phenolic formulations lose much more activity than others in changing from a nonporous to a porous surface (*8*).

Table 2. Effect of surface porosity in reducing antimicrobial efficiency of disinfectants

Germicide	Bactericidal activity [1]			(B)/(A)	(C)/(A)
	Stainless steel (A)	Asphalt tile (B)	Battleship linoleum (C)		
Phenolic A	1:50	1:25	1:10	0. 50	0. 20
Phenolic B	1:100	1:5	1:5	0. 050	0. 050
Phenolic C	1:125	1:25	-------	0. 20	-----
Phenolic D_1	1:100	1:25	-------	0. 25	-----
Phenolic D_2	1:200	1:50	-------	0. 25	-----
Cresylic	1:100	1:100	1:10	1. 0	0. 10
Coal tar	1:120	1:10	-------	0. 083	-----

[1] Dilutions of formulation required to reduce *Micrococcus pyogenes* var. *aureus* to 99.99 percent of original number in the presence of serum.

SOURCE: Reference 8.

The extent of this loss is apparently determined by the nature of the porous surface since significant differences in activity are observed on materials such as asphalt tile, battleship linoleum, soapstone, and wood. In most instances, chemical interaction between surface and germicidal agent is not observed and it seems valid to infer that porosity per se accounts in a large measure for these differences.

Superficial observation of the effective dilutions of germicides required for disinfection of the various porous surfaces (table 2) shows that impractically high concentrations are needed in many instances. Also, a different use-dilution of the same disinfectant may be required for each porous surface. Obviously, it is not practical to employ such a multiplicity of use-dilutions with a disinfectant product. Some alternative procedure must be used to combine antimicrobial effectiveness and simplicity of operation.

Studies on this point have revealed that the effectiveness of the use-dilution recommended for a nonporous surface can be enhanced on a porous surface by the use of long exposure times and by successive treatments of the surface with germicide (*9*, *10*).

As might be expected, the reduction of microbial numbers increases with length of exposure time and continues even after drying of the disinfectant is visibly completed. However, the time relationship is not linear, and after the first 10 minutes of exposure, the survivor curves tend to become asymptotic. For all practical purposes, the effective reduction in numbers is reached after the first 30 minutes.

Two successive applications of disinfectant are more effective than a single prolonged application in most instances, although the same pattern of initial rapid action followed by an asymptotic rate of reduction is encountered. With some disinfectants it appears that many successive applications on porous surfaces are required to achieve the same degree of effectiveness as attained on a nonporous surface such as stainless steel. At any rate, a significant increase in efficacy can be obtained by the use of long exposure times and successive germicidal applications, thus permitting a single use-dilution of disinfectant to be employed on a wide variety of surfaces.

Cumulative Effect

A daily routine program of applying disinfectants to floors produces an enhanced sanitary effect. Apparently, each successive daily application provides a prolonged residual of disinfectant which contributes to the antimicrobial efficiency of the next application (*9*). The degree of contribution is undoubtedly a function of the rate of evaporation, that is, vapor pressure, of the particular product since formulations vary rather widely in this respect. Ambient relative humidity is also of significance

Table 3. Physicochemical properties of formulations displaying various degrees of retention of bactericidal activity on changing from a nonporous to a porous surface

Germicide	Comparative order of efficiency [1]			
	Surface tension depression [2]	Spreading wetting [2]	Detergency [2]	Retention of bactericidal activity [3]
Cresylic	2	1	2	1
Coal tar	6	6	6	6
Phenolic A	4	5	3	2
Phenolic B	7	7	7	7
Phenolic C	5	4	1	5
Phenolic D_1	1	[4] 2–3	[4] 4–5	[4] 3–4
Phenolic D_2	3	[4] 2–3	[4] 4–5	[4] 3–4

[1] Relative effectiveness of the seven germicides for each of the indicated properties. 1 = most effective; 7 = least effective.

[2] See reference 12 for techniques and details.

[3] Based on ratio of bactericidal activities on porous and nonporous surfaces. See table 2.

[4] These products gave identical results in the indicated tests.

in this regard (*11*, *12*). With many disinfectants the residual is sufficient to kill small numbers of organisms without the aid of additional disinfectant after contamination (*2*, *9*, *11*). Such an effect may be of importance in the elimination of dustborne hemolytic streptococci and other organisms in hospital wards, dispensaries, and the like.

Formulation Properties

As noted above, disinfectant formulations, even of the same chemical type, vary widely in the degree of antimicrobial activity retained on a nonporous as compared to a porous surface.

These variations in retention of activity have been shown to be due, at least in part, to differences in certain physicochemical properties of formulations (*12*): surface tension depression, spreading wetting and detergency. Although a quantitative correlation between retention of activity and any of these properties could not be demonstrated, some relationship was noted (table 3).

Products with poor or excellent retention were found to possess relatively poor or excellent efficiencies in the physicochemical properties. This relationship is, perhaps, not unexpected since surface tension depression, wetting, detergency, suspending power, emulsification, and other similar properties contribute in various degrees to the penetration and cleansing of porous surfaces. Superior penetration and disinfection of the crevices and pores of surfaces such as battleship linoleum or asphalt tile would be anticipated with a product outstanding in the above physicochemical properties. Undoubtedly, the failure to establish a concise correlation shows a complex interrelation of the many physicochemical properties which contribute to disinfection.

Ortenzio and associates (*13*) have also emphasized the importance of the physicochemical properties of formulations in disinfection. A graphic demonstration of the enhancement of disinfectant efficiency was shown by the addition of small amounts of cleaners and sequestering agents to various types of disinfectant use-dilutions. The enhancement was believed to have resulted from an improvement in the soil suspending and dispersing properties of the solution. The authors concluded that consideration should be given to requiring certain standards for soil suspending and dispersing properties of disinfectants when a combined cleaning and disinfecting action is claimed on the label.

Unfortunately, many commonly employed laboratory methods for determining disinfectant activity present an array of physicochemical factors which bear little or no relationship to those encountered when the disinfectant is used in practice, although a tendency has been noted more recently to employ simulated use procedures. Further effort should be devoted to a study of such procedures and to the development of formulations having physicochemical properties which enhance antimicrobial effectiveness in use.

Precleaning

On superficial examination, it might be expected that precleaning of a contaminated surface prior to disinfection would produce a much more effective process than disinfection without precleaning. However, there are certain obvious objections to such a process. In some in-

stances, the handling of infectious matter without disinfectant protection during manipulation of swabs and buckets while precleaning may be a potentially hazardous operation. Also, the additional work of precleaning detracts from the simplicity of the operation. The presence of cleaner residues may deleteriously affect subsequent disinfection if an intermediate rinsing step is not employed. The inclusion of such a step adds still more complexity to the operation. Other disadvantages can be detailed. Nevertheless, it seemed of significance to study a number of phases involving precleaning.

The efficiency of mechanical removal of micro-organisms from surfaces by cleaners has been shown to be a function of the porosity of the test surface. Flannery and associates (*3*) observed that, using standard Navy soap powder, dried white oak was more difficult to decontaminate than soapstone; stainless steel was most easily decontaminated of the three surfaces studied. No significant difference was found when four different types of cleaners, white floating soap, a non-ionic detergent, trisodium phosphate, and Navy soap powder, were tested under comparable conditions on a white oak surface.

Surprisingly large numbers of organisms were shown to resist removal by mechanical cleaning. For example, after six successive washings of an artificially contaminated porous oak surface, approximately 2–6 percent of the original number of organisms still remained on the wood. Assuming an initial arbitrary load of 2,000,000 organisms per square inch, a relatively large number, 40,000–120,000, would still be present after precleaning in such cases. Although decontamination of stainless steel was more easily accomplished (99.90–99.98 percent of original cell numbers removed by two washings), small numbers of organisms could still be recovered from the nonporous surface even after six consecutive washings. The concentration of the cleaner affected the efficiency of removal in some instances, but the differences were not striking.

Evidently, mechanical removal of microorganisms by precleaning does not obviate the need for a very efficient disinfectant. Further data on this point are shown in table 4. An artificially contaminated soapstone surface was precleaned (one wash) with trisodium phosphate and then disinfected with various levels of sodium hypochlorite or the quaternary ammonium germicide, alkyl (C_8H_{17}–$C_{18}H_{37}$) dimethyl benzyl ammonium chloride (*3*). In no case was complete elimination of all test or-

Table 4. Efficiency of halogen and quaternary ammonium disinfectants in decontaminating soapstone after one precleaning step with 0.2 percent trisodium phosphate [1]

Dilution of disinfectant used	Sodium hypochlorite				Alkyl (C_8H_{17}–$C_{18}H_{37}$) dimethyl benzyl ammonium chloride			
	Percentage reduction (all organisms)	Percentage positive swabs in qualitative tests			Percentage reduction (all organisms)	Percentage positive swabs in qualitative tests		
		SS	SF	TI		SS	SF	TI
1:10,000	91. 7	100	100	100	94. 5	100	100	100
1:5,000	99. 6	100	100	25	97. 8	100	100	100
1:2,500	99. 5	50	100	25	97. 7	100	100	100
1:1,670	99. 88	50	100	25	97. 3	100	100	100
1:1,250	99. 88	0	100	25	97. 8	100	100	100
1:1,000	99. 84	0	100	25	99. 1	50	100	100

[1] 12- x 24- x 2-inch block of soapstone contaminated with mixture of three test organisms and soil. Surface washed once with 0.2 percent trisodium phosphate, the cleaner drained off, and the area disinfected with indicated disinfectants. Standard (4″ x 4″) areas then swabbed, the swabs rinsed in water and then incubated in appropriate differential media. "Percentage reduction" refers to number of organisms recovered in swab rinse water. "Percentage positive swabs" refers to total number swabs which were positive after incubation. SS=*Salmonella schottmuelleri;* SF=*Streptococcus faecalis;* TI=*Trichophyton interdigitale.*

Source: Reference 3.

ganisms achieved with one application of either germicide up to concentrations of 1,000 p.p.m. after precleaning. Antimicrobial effects were initially observed at 200 p.p.m. halogen and 1,000 p.p.m. quaternary.

It was concluded: "The concentrations of germicides necessary to produce disinfection of soiled surfaces after cleaning by a swab-washing procedure (with the exception of highly polished surfaces such as stainless steel) appear to be from three to five times as great as those commonly accepted for use as final germicidal rinses for dishes and glasses in restaurants, and utensils and equipment in dairies and food plants."

The latter portion of this quotation is of significance in that hypochlorites and quaternaries are used primarily as sanitizing agents, and it was desired to relate in some fashion recommended sanitizing use-dilutions with effective disinfecting operations.

In general, the data in tables 2 and 4 (*3, 8–10*) indicate that the porosity of the test surface is of prime importance in deciding the effectiveness of a precleaning operation in reducing the load on the disinfectant subsequently employed. Porous surfaces can be more easily decontaminated when precleaned, but relatively strong concentrations of germicide are still required in the subsequent disinfecting operation. Unfortunately, precleaning appears to be most effective under conditions in which disinfection alone can be readily accomplished, that is, on a nonporous surface. It is questionable whether precleaning is worth the effort under such conditions, assuming that an effective disinfectant at proper concentration is ultimately employed.

Effect of Cleaner Residues

As noted above, residues from precleaning procedures may affect deleteriously subsequent disinfection if such residues are not thoroughly removed by rinsing. Ortenzio and co-workers (*14*) have demonstrated the extent of this inactivation using quaternary ammonium and phenolic disinfectants.

As expected, the chemical nature of the cleaner determines the extent of inactivation. Soaps are more deleterious to quaternaries than phenolics, and the reverse is true for non-ionic detergent cleaners. When the cleaner and disinfectant are "incompatible," as much as 2.5 times more disinfectant is needed to produce the same antimicrobial effect as in the case of a "compatible" combination. Even alkaline inorganic cleaners, such as trisodium phosphate and sodium carbonate, may seriously inactivate quaternary ammonium disinfectants if soil containing fat is present, presumably due to formation of traces of soap.

It is apparent that an effective precleaning procedure, if employed, must be discriminately chosen and be properly performed.

Waxing

Since the practice of waxing surfaces is widespread in civilian and military establishments where pathogenic micro-organisms may be of significance, the effect of such a practice on subsequent disinfection has been determined (*9*). Surprisingly, the antimicrobial effectiveness of disinfectants on a waxed linoleum surface was not found to be strikingly different from an unwaxed surface. This was attributed to the failure of the wax to form a microscopically smooth outer layer and, in effect, transform the porous linoleum surface into a nonporous one. The waxed surface was significantly scratched and pitted after the waxing operation, presumably, because of the action of the buffing machine and solvent evaporation. For all practical purposes, the waxed surface was still porous.

Quite recently, "germicidal" floor waxes have been placed on the market. Such products consist of self-polishing water emulsion waxes with germicidal agents added (*15*). Present formulations list either a quaternary ammonium or a phenolic disinfectant as the biologically active ingredient. Possibly, these products act physically in a manner similar to "insecticidal" waxes which have been in use for a number of years: The biologically active material slowly leaches to the surface of the wax and provides an insecticidal or germicidal outer layer.

Since only preliminary data are available on the efficacy of germicidal floor waxes, a definitive conclusion on their usefulness cannot be made at present. However, it has been shown that these formulations are capable of eliminating small numbers of organisms which are de-

posited on wax-coated surfaces in simulated-sneezing experiments (*15*). Probably, moisture is required for a lethal action to occur, as in the case of all known antimicrobial agents, and ambient relative humidity may play a significant role.

The degree of effectiveness may be equivalent at best to that of disinfectant residues remaining on surfaces as a result of a routine daily treatment, but significant elimination of gross contamination deposited on surfaces coated with germicidal waxes without further addition of a disinfectant seems distinctly improbable. The exact role of these agents in environmental sanitation must await further study.

Summary and Conclusions

The salient points obtained in an extensive investigation of floor disinfection conducted by the Department of the Navy have been presented. The implications of other current findings in the literature have also been integrated and presented.

Using test procedures that attempt to simulate use conditions, investigators determined that the degree of efficiency of disinfectants used on floors is influenced markedly by the porosity of the floor surface. Certain representative chemical types of disinfectants were shown to be deficient in antimicrobial activity particularly in regard to species specificity. With synthetic phenolic formulations, the efficiency of disinfection of porous surfaces is related significantly to the physicochemical properties of the formulation. However, by long exposure times or by successive treatments with germicide, a significant reduction in microbial numbers on a porous surface can be achieved. Waxing of porous surfaces apparently does not alter strikingly the efficiency of disinfection attained on the unwaxed surface. A daily routine of disinfection contributes significantly to the ease with which porous surfaces can be decontaminated.

Studies on the effect of precleaning surfaces before disinfection have shown that the efficiency of the cleaning operation is also intimately related to surface porosity. Unfortunately, the contribution of precleaning to the disinfecting process is greatest on nonporous surfaces which are, in themselves, relatively easy to decontaminate by a single application of germicide. The types of cleaner and disinfectant employed must be carefully chosen since residuals of cleaner remaining may seriously inactivate the germicide if the two are incompatible.

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Shellfish Sanitation Workshop

A Shellfish Sanitation Workshop, held in Washington August 27 and 28, 1956, had a registered attendance of 58. Fourteen States were represented by 18 persons. The oyster industry was represented by 6 persons designated by the Oyster Institute of North America and by 2 representatives from the National Fisheries Institute. The Canadian Government had two representatives (Department of National Health and Welfare, and Department of Fisheries). Other agencies or organizations with representatives present included the Public Health Service, Departments of Army, Navy, and Air Force, Food and Drug Administration, Fish and Wildlife Service, American Cyanamid Co., and the University of Maryland. The Association of State and Territorial Health Officers was represented by Dr. Mack I. Shanholtz of Virginia.

The manual of recommended practice for sanitary control of the shellfish industry, as revised at the meeting, was unanimously adopted by the workshop for use as a guide in the cooperative shellfish certification program.

On the basis of studies made by the Canadian Department of National Health and Welfare, the Maryland Department of Health, the Virginia Department of Health, and the Public Health Service Shellfish Sanitation Laboratory, a 1-year interim bacteriological market standard, was adopted for shucked oysters. This interim standard is the first of its kind in the 31-year history of the shellfish program and establishes three categories of evaluation:

Category	*Coliform MPN*	*Standard plate count*
Acceptable.....	Not more than 16,000 per 100 ml.	Not more than 50,000 per ml.
Acceptable on condition.[1]	Less than 160,000 per 100 ml.	Less than 1,000,000 per ml.
Rejectable.....	160,000 or more per 100 ml.	1,000,000 or more per ml.

[1] Shipments will be reported to the shellfish control organization of the originating State for investigation and will not be rejected unless the report of the investigating authority is unsatisfactory.

The workshop also considered effects of the dis- Public Health Service to undertake an investigation of organisms other than coliforms as indicators of the sanitary quality of shellfish.

The workshop also considered effects of the disposal of wastes from cabin cruisers and other shipping. Harold F. Udell, New York State Department of Conservation, estimated there were approximately 15 to 16 thousand pleasure craft equipped with toilet facilities and registered in the Marine District of the State of New York.

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